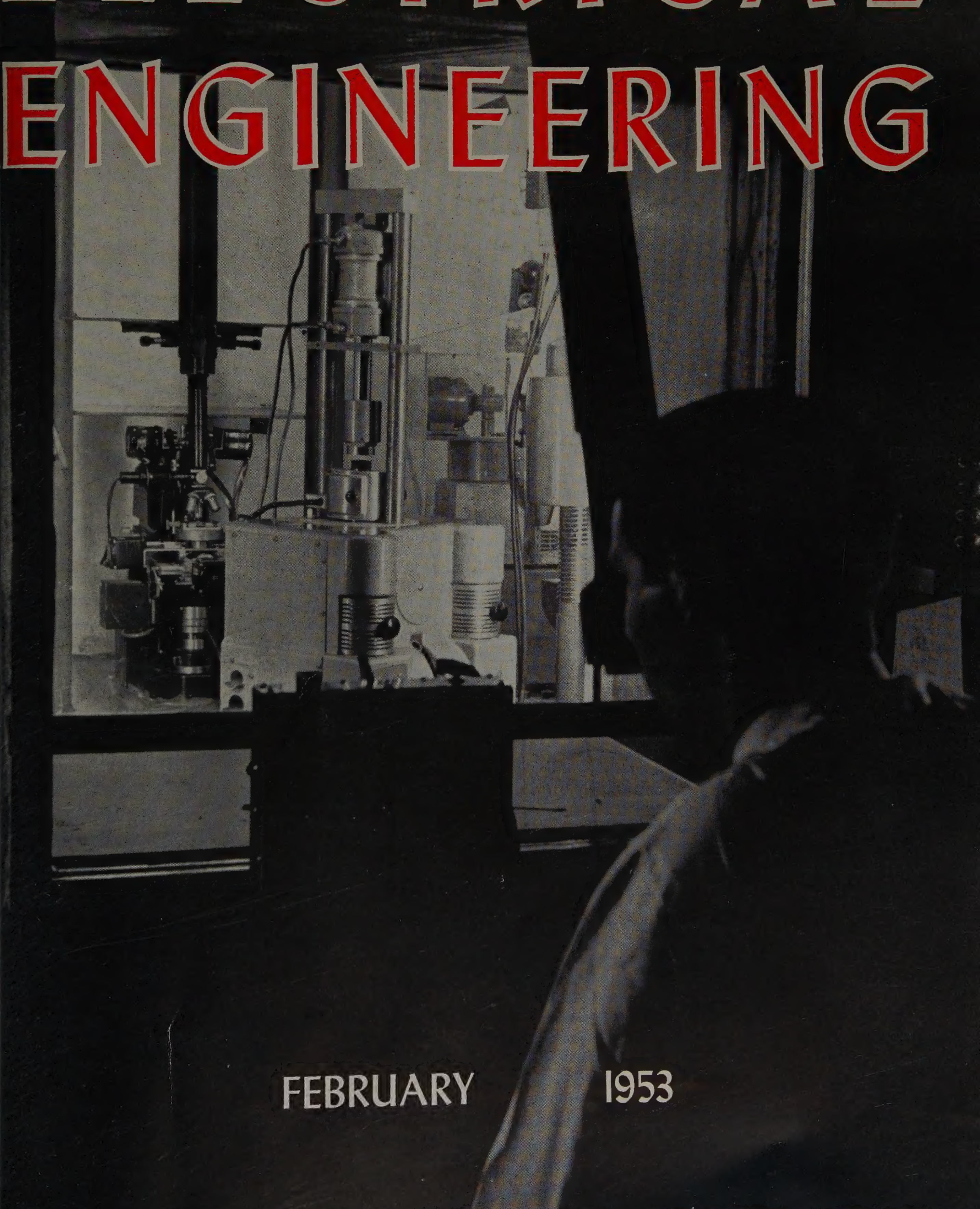
ELECTRICAL ENGINEERING



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ELECTRICAL ENGINEERING

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The Cover: A Westinghouse engineer uses a "long-range" microscope to measure the effect of radioactivity on the hardness of a specimen. See "Of Current Interest" section, pages *180–1*.

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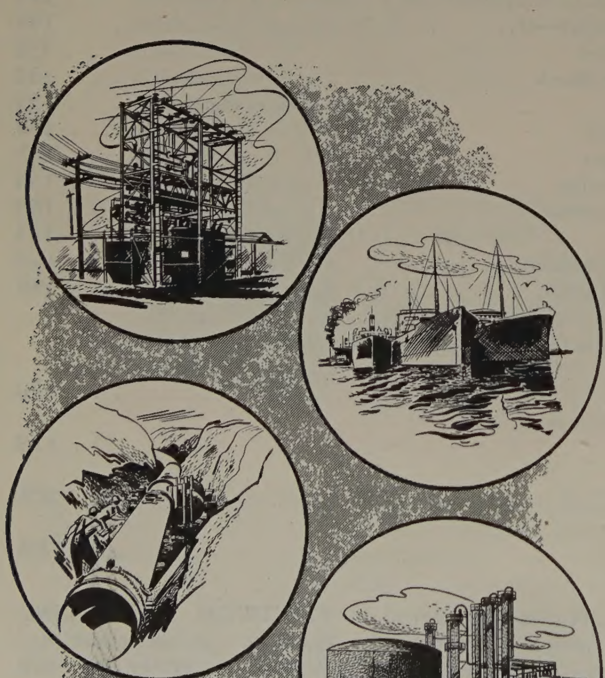

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The International Electrotechnical Commission

H. S. OSBORNE
FELLOW AIEE

The International Electrotechnical Commission is concerned with the development of international agreement on electrical standards. The president of the Commission reports herein on actions taken at the organization's recent meetings in Holland.

THE International Electrotechnical Commission (IEC) is the medium through which representatives of the electrical industries and electrical science in the various countries of the world co-operate in the preparation of international recommendations for standards. These standards cover a wide range of types of electric apparatus and systems, and include also electrical terms, units, and graphical symbols. The development of these standards through the voluntary action of the electrical industry in the various countries is important in the stimulation of international trade and in the development of a better understanding among those associated with the electrical arts and sciences throughout the world. The technical work of the IEC is carried out by technical committees, now 38 in number, each of which is assigned the task of developing standards in one branch of the subject.

MEETINGS AT SCHEVENINGEN

IN AN UNUSUALLY PRODUCTIVE series of meetings, 26 technical committees of the International Electrotechnical Commission discussed international agreement on electrical standards at Scheveningen, Holland, in September 1952. Nineteen countries were represented by 418 delegates. The United States, represented by 14 delegates, participated in almost all of the technical meetings. Great Britain was represented by 61 delegates and France by 51.

Accepting an invitation from the Yugoslav National Committee, the IEC decided to hold its 1953 meetings at Opatija on the Istrian Peninsula. These meetings will be scheduled for 2 weeks beginning June 22. The 1954 meetings will take place in the United States to celebrate the Commission's 50th anniversary.

Among important actions taken in 1952 at Scheveningen was the authorization of a new technical committee to develop standards for electronic tubes. Standards for radio tubes heretofore have been part of the duties of the Technical Committee on Radio. Organization of the new committee recognizes the fact that the use of electronic tubes has now extended into a much broader field than radio alone. This follows the development of standardization in the United States. Holland was assigned the secretariat for the new committee.

A number of standards were completed and will be submitted to the national committees for approval. These include revision of the specifications on rotating electric machinery; preferred standards for 50-cycle turbines and for 3,000-rpm 3-phase 50-cycle turbine-type generators; a basic list of graphical symbols; a revised list of standard voltages; power losses and methods of expressing efficiency of electric equipment; safety rules for amplifiers and loudspeakers; several standards for radio components; temperature rise for circuit breakers under normal loading conditions; a revision of standards for power capacitors; dimensions of electronic tube bases and gauges; and two specifications for high-voltage insulators.

The IEC Council, the Commission's governing body, and the Committee of Action, its executive committee, considered strengthening co-operative relations between the IEC and other international organizations. Arrangements were made for extending co-operative action on standards of joint interest to IEC and the International Commission on Rules for the Approval of Electrical Equipment (CEE). This is a European organization developing safety rules for radio receivers, loudspeakers, amplifiers, television receivers, wiring devices, and similar equipment. It is now extending its activities into other fields closely related to those covered by IEC. The rules adopted by CEE are used by some European governments in inspection and approval of electric equipment.

Closer co-ordination of IEC work with that of the International Organization for Standardization was discussed also.

A request from the Organization for European Economic Co-operation (OEEC) for the fastest possible progress on projects which OEEC believes would help in stimulating international trade was given serious consideration. These are in the field of light electric equipment, including domestic appliances for room heating and cooking, protective devices for motors, medical appliances and X-ray apparatus for medical use, arc welding apparatus, measuring instruments, radio receivers, and interference suppression devices. In most cases there are now differences in standards used by different countries for these types of equipment. The request is being passed along to the secretariats for the projects in question and arrangements are being made for close liaison with OEEC in the future.

The volume of work handled by technical committees has increased so rapidly that the Central Office of IEC

H. S. Osborne, president of the International Electrotechnical Commission, recently retired as chief engineer, American Telephone and Telegraph Company, New York, N. Y.

finds it difficult to meet the expense of translation, duplication, and distribution of documents. An attempt will be made for the present to meet the problem by asking the national committees to handle a larger amount of this work rather than by increasing the scale of support. It is recognized, however, that this may cause difficulty, particularly in securing accurate translations of highly technical matter between French and English.

Suggestions for new work considered by the Committee of Action included expansion of the project on graphical symbols and increased activity on switchgears to include contactors, starters, bus bars, switchgear assemblies, and the like, both for low and high voltages, except for domestic installations. Work on electroacoustics was revitalized and the secretariat of the technical committee transferred from the British National Committee to the Netherlands Electrotechnical Committee.

IEC technical committees reported their activities at the Scheveningen meetings as follows:

Nomenclature (*TC 1*). Progress is being made toward completion of the vast task of revising and expanding the "International Electrotechnical Vocabulary" published by IEC in 1938. Definitions are to be in English and French, with the terms themselves in six languages. The committee hopes to complete its task in 1954. An improved procedure to expedite the work, proposed during 2 weeks of meetings at Brussels, Belgium, immediately preceding, was approved at the IEC meetings at Scheveningen.

Rotating Machinery (*TC 2*). Two draft specifications were completed by the technical committee. One was on rotating electric machinery (a revision of IEC Publication *34*), the other on preferred standards for 3,000-rpm 3-phase 50-cycle turbine-type generators. The new Publication *34* now covers rotating electric machines of all types without limitation as to output or voltage, with the exception of machines for use on railway vehicles. The 1935 edition of Publication *34* which it revises also covered transformers. These are now taken care of by a separate technical committee, *TC 4*. The revisions incorporated in the standard comprise a complete review and modernization of the basic standards for rating and testing rotating electric machinery.

The Subcommittee on Dimensions for Motors has reached agreement on height to center-lines. The dimensions agreed on are consistent with both European and American practice. At the present time it has not been possible to reach agreement on other dimensions. Work is continuing, however. A report on the work to date is to be published.

The Subcommittee on Classification of Insulating Materials proposes to standardize a new class of insulation between the established Classes *A* and *B*. The new class, to be designated Class *E*, will have an allowable temperature of 120 degrees centigrade. This is not in accordance with American views. The general feeling in Europe, however, is that more classes of insulation are needed in order to economize on materials by using every material at as high a temperature as it will stand.

A subcommittee dealing with power losses and methods of expressing efficiency agreed upon a draft which will be circulated for approval by the national committees.

Graphical Symbols (*TC 3*). Recognizing that a general review of all previously published graphical symbols will require a great deal of work over a long period of time, the committee concentrated on 80 basic graphical symbols in common use. Agreement was reached and the 80 symbols are being submitted to the national committees for approval.

The committee was given approval to widen its scope to include classification of circuit diagrams and statement of principles governing the use of symbols in different types of diagrams.

Steam Turbines (*TC 5*). A subcommittee completed work in connection with nonreheat turbines and 50-cycle reheat turbines. (This is complementary to work done by *TC 2* on 50-cycle generators.) The proposed standard is now going to the national committees for approval.

Standard Voltages (*TC 8*). A revision of the IEC list of standard voltages was agreed upon and will be submitted to the national committees. The most important item is the range of system voltages above 1,000 volts. Because of irreconcilable differences between European and American practice, two series are given for nominal system voltages below 60 kv, one representing European practice and the other American practice. For voltages higher than the 60 kv, a single series of voltages was found acceptable.

The practical significance of the difference in voltages used in different countries is to be studied by a new subcommittee. The object is to reduce the number of these different voltages.

Further work is to be done in standardization of voltages below 100 volts and also of system frequencies above 60 cycles per second.

Radio-Communication (*TC 12*). This committee and its subcommittees met throughout a period of more than a week.

Safety rules for amplifiers and loudspeakers, drafted by the Subcommittee on Safety, will be circulated to the national committees for approval. Safety rules for television receivers were given preliminary consideration.

A Subcommittee on Components completed several documents which will be circulated for approval. These include basic testing procedure for climatic and mechanical robustness of components, specifications for fixed tubular paper capacitors, and a draft color code for ceramic capacitors. In addition, several group specifications for the guidance of the committee in preparing further standards were agreed upon. The committee made plans for a large program of future work.

A subcommittee on electronic tubes completed a specification for the dimensions of tube bases and gauges. Considerable progress was made on systems for designating types of tubes. It was agreed to proceed further on the basis of the American system of tube designation after completion of revisions now under way. The increased use of electronic tubes in many fields was recognized by the IEC Committee of Action. It set up a new technical

committee to develop standards in the entire field of electronic tubes, including radio tubes heretofore handled by Technical Committee *12*.

Insulating Materials (*TC 15*). A considerable part of the work of this committee was in co-operation with the Subcommittee on Insulating Materials of *TC 2*, Rotating Machinery. The Committee of Action assigned to *TC 15* the general study of classification of insulating materials. It was understood that committees dealing with specific types of apparatus, while using the work of *TC 15* for guidance, are left at complete liberty to establish their own standards for insulation applying to the types of apparatus with which they are dealing.

TC 15 also gave consideration to essential apparatus and techniques for testing the electrical strength of insulating materials. It reached agreement regarding dimensions of test electrodes and related matters. Plans were made for the very large amount of future work which is in the field of this committee's activities.

Switchgear (*TC 17*). The section of the standards for circuit breakers dealing with temperature rise for normal loading conditions was completed and will be submitted to the national committees for approval.

The standard on Rules for Short-Circuit Conditions now being reviewed by the various national committees will be published as soon as approval is received.

The Committee of Action approved the recommendation of *TC 17* that its scope be extended to include voltage equipment and auxiliary equipment, with the exception of equipment used for domestic and similar installations. This field is covered by Technical Committee *23*, Electrical Accessories. A subcommittee was set up to start work in the new field being undertaken by the committee.

Electronic Devices (*TC 22*). In the interest of clarity, the Committee of Action changed the title of this committee to "Power Converter Equipment Other Than Rotary Converters and Motor-Generator Sets."

Material progress was made at these meetings in the preparation of specifications for ionic converters. More work is necessary before the complete specification can be recommended. The committee hopes to continue this in a spring meeting to be held either in Paris, France, or London, England.

Co-ordination of Insulation (*TC 28*). Recommendations for the co-ordination of insulation in exposed locations on high-voltage a-c systems are being prepared. Excellent progress in this difficult and controversial subject was made during these meetings. The basic aim of the committee is to define such co-ordination of insulation as will avoid damage to electric equipment due to overvoltages and limit unavoidable flashovers to points where they will cause no damage.

Power Capacitors (*TC 33*). A number of suggestions from the United States were considered. These covered changes in draft specifications for shunt capacitors for power systems. These draft specifications have been in trial use. Revisions were made which incorporated most of the United States proposals. The revised draft was approved for circulation to all the national committees for their approval.

Dry Cell Batteries (*TC 35*). This committee made substantial progress in the development of standards for dry cell batteries, including definitions, dimensions and tolerances, conditions of test, and performance required under these tests. Further work is continuing.

High-Voltage Insulators (*TC 36*). Two specifications were completed; they will be submitted to the national committees for approval. These were: International Specifications for Porcelain Insulation for Overhead Lines With a Nominal Voltage of 1,000 Volts and Upward, and International Specifications for Glass Insulators for Overhead Lines With a Nominal Voltage of 1,000 Volts and Upward.

There was considerable discussion of the utility of the sphere gap as a measuring device. It was agreed that the sphere gap tables should be extended upward, but that other methods of measuring high voltages also should be studied.

SUMMARY

No report would be complete without a word of appreciation for the excellent arrangements made by the Netherlands Electrotechnical Committee and the delightful entertainment which they provided both for the delegates and their families.

The excellent work of the American delegates also should be commended. This extends to the numerous groups under American Standards Association sectional committees and in the various branches of the electrical industry who did the large amount of preparatory work necessary to make possible the good work of the American delegates at the international meetings.

The rapid increase in the volume of work being done by the various IEC committees is indicative of the increasing importance of international standards in the stimulation of international trade and of the growth of international understanding in a complicated and rapidly developing art. The United States has shared in this growing interest in the work. The delegation to the meetings at Scheveningen this summer was the largest American delegation of recent years. In addition, American representatives have taken part in a number of the meetings of individual committees during the year.

The reactions of the United States delegates have been well summarized in their individual reports. Following are observations made by two of the delegates to the meetings:

1. There appears to be genuine interest in international standardization. No delegate pushed too hard for his own standards. There was a wholesome spirit of co-operation.
2. The opinion of the United States is highly valued by the delegates.
3. The need to conserve material is more urgent in Europe than in the United States and there is a tendency to work material harder and work closer to established

limits, even at the expense of having more items in the standards.

4. Gathering in meetings such as this accomplishes more than could be accomplished by correspondence. One gets to know the delegates from other countries and can better understand their viewpoint. For this reason it would be helpful if a delegate could attend such meetings for at least 2 successive years.

5. The United States can be very influential in this work but it will be necessary for the United States to take a genuine interest and actively prosecute such work. We feel that we are not doing as much in this respect as we should.

6. Progress is slow, but progress is being made.

All who take part directly in the IEC conferences come home with an increased appreciation of the importance of this work of development of international standards. We also have an increased awareness of its difficulties, of the large place which American industry now has in the work, and of the value of doing even more work in the future. This international standardization benefits our own country and also benefits the other industrial countries of the world. Let us be sure we all play our full part in furthering this important and expanding movement for the stimulation of international trade and international understanding.

The Oil Industry's Progress in Louisiana

H. J. VOORHIES

After placing oil among other energy sources in the world, this article discusses its importance in Louisiana. It gives the location of the oil fields, refineries, and pipe lines, as well as modes of shipment of the major refinery products.

PROGRESS IN THE oil and electrical industries go hand in hand. Each time a new well is drilled, a new pipe line constructed, a new refinery unit built, or a new service station opened, there is an immediate increase in the demand for electric energy.

At Esso's Baton Rouge (La.) refinery, for example, more electricity is now used than is consumed by all residential customers in the city of Baton Rouge. Although electrical storms are common occurrences in this area, the new process units are being built with electric drives and without steam spares. Electrical storms, an average of 70 per year, occur more frequently on the Gulf Coast than in any other area of the United States except the Florida peninsula. Electric systems, however, are now designed to meet these conditions.

As background for the Louisiana phase of this article, some of the broader aspects of oil and its close companion, "energy," should prove helpful. Figure 1 shows data on crude oil production in the world, the United States, and Louisiana. The phenomenal growth of the industry is plainly illustrated.

ENERGY AND OIL

THE OUTSTANDING INCREASE IN THE PRODUCTION OF crude oil during the last few decades has made available a source of energy for our everyday lives which has replaced to a substantial degree the energy formerly provided by men and animals. Figure 2 shows graphically the increase in our dependence on machines during the last century. It is estimated that by 1960, 96 per cent of all energy will be supplied by machines.

In addition to oil products, water power and coal are the major sources of energy today. Figure 3 indicates the roles played by each of these respective sources of energy. It is immediately apparent that petroleum and natural gas have displaced coal as the major fuel.

The reasons which are commonly recognized for the change to petroleum and natural gas as the number one source of fuel in the United States are (1) ease and convenience of storage and transportation, (2) reliability of supply, (3) the absence of ash, and (4) cleanliness. A factor not so commonly recognized is the higher thermal

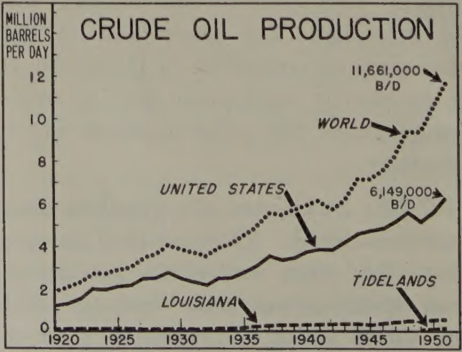


Figure 1

H. J. Voorhies is vice-president and general manager of the Baton Rouge Refinery, Esso Standard Oil Company, Baton Rouge, La.

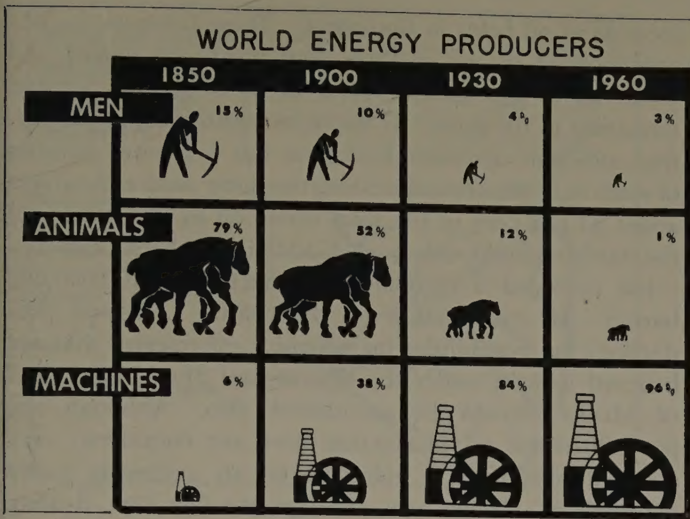


Figure 2

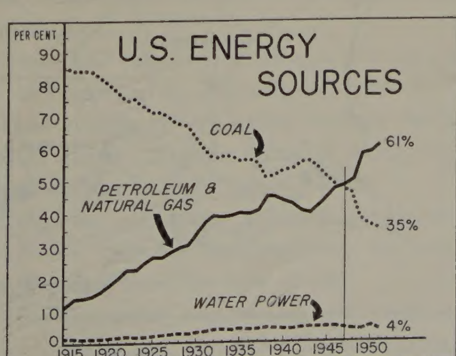
efficiency obtained in many applications through the use of oil or gas products as compared with coal. This difference in thermal efficiency is particularly striking in the transportation field.

The thermal efficiency of coal and petroleum as locomotive fuels is compared in Figure 4. Petroleum, through the diesel-electric engine, provides more than six times the thermal efficiency provided by coal through the steam engine. Data of this sort explain why at least one of the major locomotive companies has recently stopped producing steam engines and why over 95 per cent of the new locomotives on order are diesel-electric. Projecting today's trend forward, on a freight ton-mile and a passenger train-mile basis, it is expected that by 1955 the railroads will have converted almost 90 per cent to diesel energy. See Figure 5.

One instance in which coal is being displaced by a petroleum product has been mentioned. But short-term situations sometimes favor coal. As one example, modern utility producers on the East Coast normally change from petroleum to coal when the price of Bunker "C" Fuel Oil rises above $2.10 per barrel. The price of Bunker "C" in the New York Harbor ranged between $1.90 and $2.05 per barrel during the first half of 1950, but increased by the middle of 1951 to $2.45 per barrel.

Many utility producers consequently converted to coal, and in 1951 about 1/3 less fuel oil was used for the generation of utilities than in 1950. The accumulation in petroleum industry tankage of inventories of this heavy fuel which could not find a market at $2.45 caused a series of price breaks in 1952 back to a current New York Harbor price of $2.10 per barrel. This illustrates the economic conflict continually in progress between the various alternative sources of energy.

Figure 3



LOUISIANA AND OIL

When Napoleon sold the Louisiana Territory to the United States in 1803 for the sum of $15,000,000, little did he realize that 1 to 3 miles beneath the soil of this vast block of land lay one of the products of nature which was destined to revolutionize the life of the world. Only a century and a half later the State of Louisiana produces about 668,000 barrels of crude oil worth a million and a half dollars every day. This means that Louisiana, which is only a small portion of the original Louisiana Purchase, pays off the debt to Napoleon every 10 days. Louisiana crude oil production now represents more than 10 per cent of United States domestic production and about 6 per cent of world crude oil production.

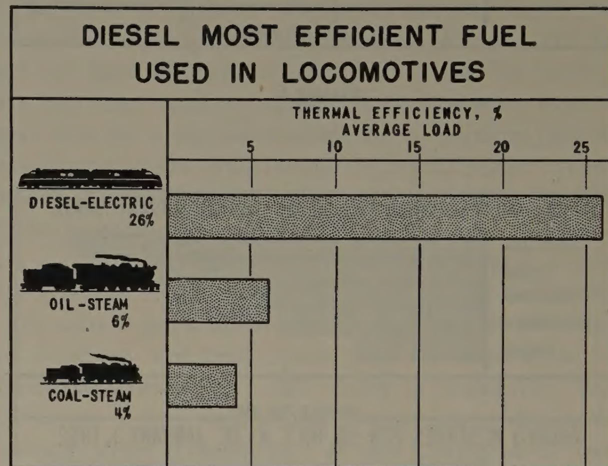


Figure 4

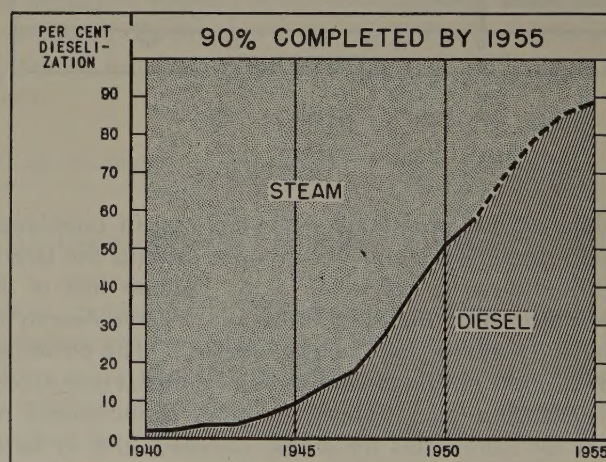


Figure 5

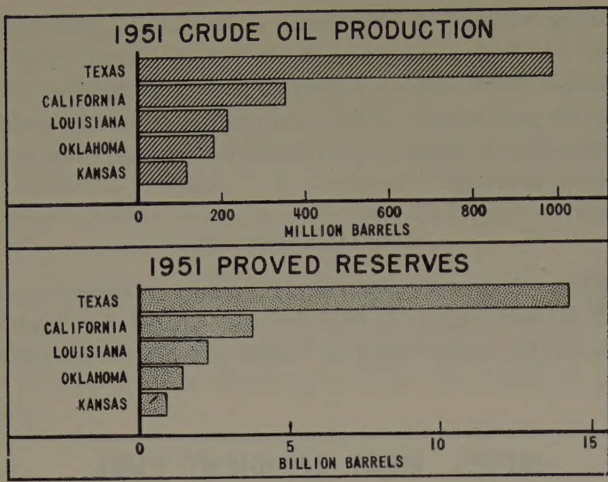


Figure 6

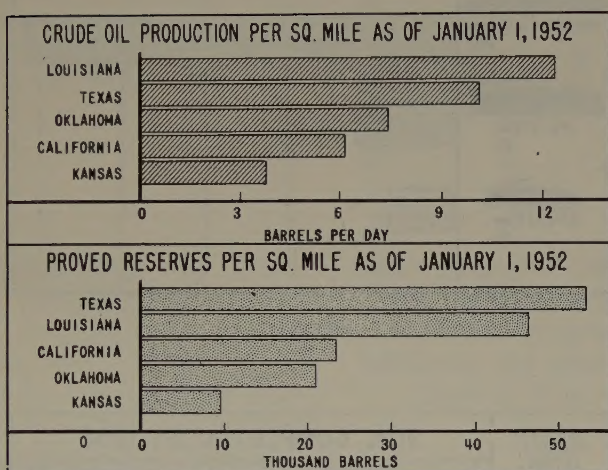


Figure 7

About 62,000 people are now employed in Louisiana's oil and gas industry and this group represents the largest single industrial group in the state. Almost half of the taxes collected by the State of Louisiana come directly or indirectly from the oil and gas industry. The combined payrolls of the oil and gas industry in Louisiana now exceed $200,000,000 a year. This is exclusive of the money received by landowners for leases, royalties, and so forth. With these basic facts in mind, it is not difficult to realize that oil plays a vital role in Louisiana's economic life.

Production. Figure 6 shows crude oil production and estimated oil reserves in the five leading oil producing states in the nation. It is significant to note in Figure 7 that Louisiana produces more oil per square mile of area than any other state in the nation. Texas may object to this type of comparison but it has its merits. Texas, however, on the basis of crude reserves per square mile of area, is slightly ahead of Louisiana. These two states stand well above the remaining states in both production and reserves on a square-mile basis.

Location of Oil Fields in Louisiana. Figure 8 shows the location of oil fields in Louisiana. These fields are largely concentrated in the southern and northwest sectors and either oil or gas is now found in 58 of the 64 parishes (counties) in the state. It might be mentioned, in passing, that although northern Louisiana has a greater number of wells than the coastal section, the latter section produces about 83 per cent of the total crude oil in the state. Of the state's oil fields, only one—Caddo in northern Louisiana—has exceeded a cumulative production of 100,000,000 barrels. In commenting on the coastal Louisiana production, the possibilities for extensive oil reserves that are believed to exist under the Continental Shelf in the Gulf of Mexico should be mentioned also. Although the possibilities for oil production here are considered very good, development is going to be an extremely costly undertaking. When you consider the fact that drilling must be done in water ranging from several feet to several hundred feet deep, it is not difficult to see the staggering costs involved.

Crude-Oil Pipe Lines. Figure 9 shows the crude-oil

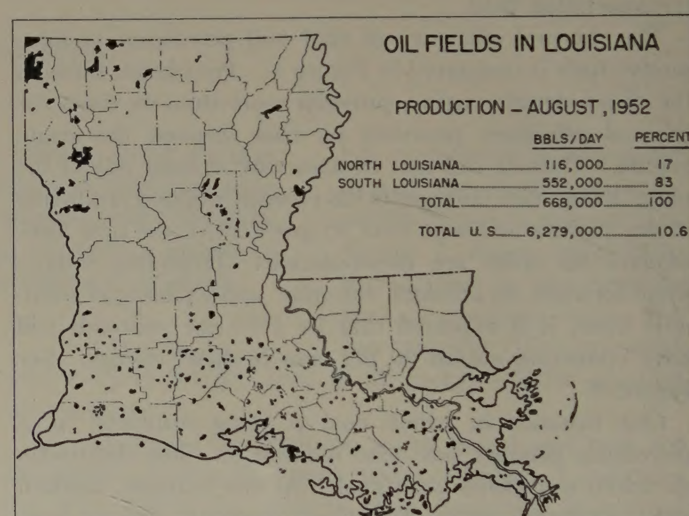


Figure 8

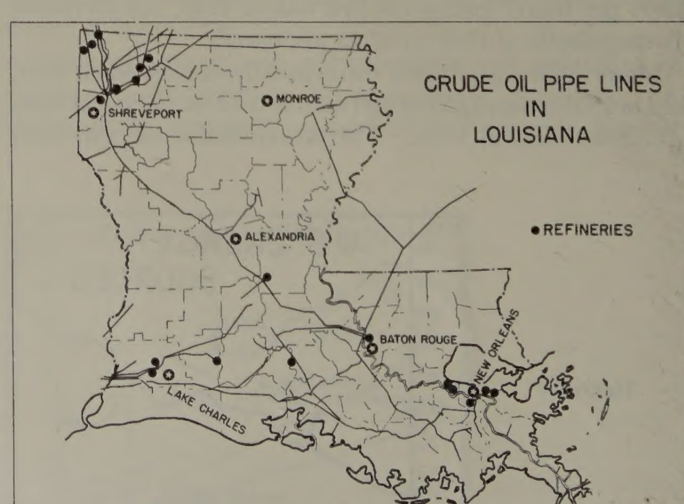


Figure 9

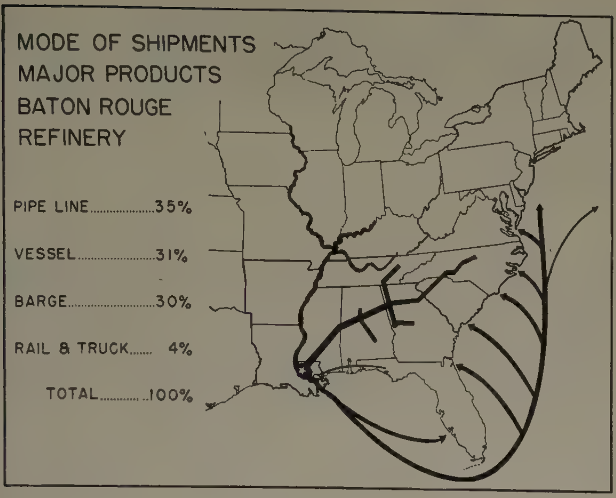


Figure 10

pipe-line system in Louisiana. The state now has more than 4,000 miles of crude oil lines. These lines range in size from 2 to 22 inches in diameter and are owned in large part by oil pipe-line companies rather than producing or refining companies. Pipe line is the cheapest method of moving oil and the majority of the state's crude oil moves to refineries or deep water terminals by pipe line. Ninety-five per cent of the crude oil for the Baton Rouge refinery comes in by pipe line.

Refineries. Figure 9 also shows the locations of refineries in this state. There are 19 refineries, 16 of which are active at this time. Louisiana now ranks third among the states in crude oil refining capacity. These refineries have a total crude capacity of approximately 500,000 barrels daily. They range in size from 255,000 barrels daily capacity at Esso's Baton Rouge refinery to the smaller plants at Breaux Bridge and Eola, which process less than 1,000 barrels per day each. The refinery at Baton Rouge, since its opening in 1909, has processed nearly a billion and a half barrels of crude oil, or the equivalent of about half of Louisiana's total crude oil production to date.

The refineries found in this state perform a variety of process functions. The Baton Rouge refinery of Esso Standard Oil is one of the largest and most complete oil refineries in the country and manufactures more than 700 different products. In two areas of the state, Baton Rouge and Lake Charles, the oil refineries have become the focus for substantial chemical developments which use the products of the refinery or furnish products to it.

Distribution of Products. Figure 10 outlines the methods of distribution of products from one refinery. We have used the Esso refinery because it is the one on which we have the most accurate data. It can be seen from this figure that the major movements are by product pipe line, ocean-going tanker, and inland waterway barge. A small amount of movement is by rail and tank truck. Louisiana consumes only about one-fourth of its daily production. As a consequence, it is necessary to move a large quantity of products to other areas of the nation and of the world.

The state is particularly well located for this movement. The relatively flat land makes pipe-line movement very effective. More than 6,000 miles of navigable water, with access to both inland and ocean-going transportation, facilitates water movements. It also is serviced by major transcontinental railroads and its highway system makes the truck convenient for short hauls.

On the basis of the figures shown here, the progress and important position of the oil industry in Louisiana is obvious, and this progress is just one indication of the very substantial economic growth in this state and the entire South.

Gas Turbine Used to Pipe Natural Gas Through Pipe Lines

The gas turbine, one of the most versatile new sources of power for industry, is being used successfully to pump natural gas through pipe lines, according to an announcement by Paul Kayser, president of the El Paso (Tex.) Natural Gas Company.

Mr. Kayser revealed that the first of 28 5,000-horsepower gas turbines for the El Paso gas transmission system between west Texas and California had been placed in operation in Cornudas, Tex.

The new gas turbines will operate centrifugal pumps to obtain an increase in capacity of 300 million cubic feet per day. The El Paso system is now using stations with reciprocating pumps at about 100-mile intervals along the line. These units will continue to be used.

The gas turbine stations are being inserted at about 30-mile intervals between existing reciprocating stations to boost the average pressure and the flow of gas.

Mr. Kayser said that operating cost of the new stations is expected to be less than the cost of present reciprocating stations, principally because the new stations will require less manpower for operation and maintenance.

Sites of the new stations are in the desert where water is a precious commodity. Gas turbines are well-suited to such locations because they require little water and few operating personnel.

The order for the gas turbines, placed with the General Electric Company, is reported to be the largest single order ever received for that type of equipment. Nine of the units are already being installed and some are already in operation. The remainder are scheduled for shipment by March of this year. All the gas turbines are expected to be in operation before the end of 1953.

Pipe lines of the El Paso concern extend from fields in New Mexico and west Texas into southern California, where they supply gas to pipe lines of the Pacific Gas and Electric Company, Southern California Gas Company, and Southern Counties Gas Company. These companies distribute gas in the San Francisco and Los Angeles areas.

Electric Power and the Atomic Bomb

PHILIP SPORN
FELLOW AIEE

Text of remarks at the ceremony attendant upon the breaking of ground for the Clifty Creek Plant of the Indiana-Kentucky Electric Corporation* at Madison, Ind., December 5, 1952.

WE HAVE MET HERE to participate in the ceremonies marking the beginning of construction of a large power plant, destined, we believe, to be one of the great power plants of the world. This plant, when completed in 1956, will generate annually close to ten billion kilowatt-hours. This is more electric energy than was utilized in 1951 in the entire state of Indiana and 33 per cent more than the energy generated in 1951 at the great Boulder Dam and at the Bonneville Dam combined. The energy will be delivered to and will be utilized in the Atomic Energy Commission's new diffusion plant now being constructed in Pike County, north of Portsmouth, Ohio. The principal objective of a diffusion plant is the separation of the two components of natural uranium so that one of them, uranium 235, becomes available in greater concentration than it is found in the natural state. The uranium 235 component is a fissionable material. It is because of its characteristic ability to undergo fission, its ability to sustain a breaking up of its atoms by a chain reaction, that it becomes highly valuable as a material for atomic bombs. Thus the electric power that we shall produce here will help make an important material—the most important material, in fact—involved in an atomic bomb.

We need atomic bombs today because the world we live in is the kind of world it is. We need atomic bombs to guard and protect ourselves against attack by those who might otherwise be tempted to attack us. We need atomic bombs to be able to retaliate in force and in kind in case, contrary to all that is decent and sensible, our enemies attack us: we must be in position to retaliate to save ourselves from complete subjugation or perhaps even extinction. The bombs that the power to be produced in this plant will help make, and this power therefore, are needed for the safety and protection of every man, woman, and child in this great land of ours, and for the defense and protection of the entire free world. For the present, we cannot do without these bombs and without this power.

Yet it is disheartening to think that so much of our great heritage as reflected in our scientific endowment, in our great manufacturing establishments, in the great array of engineering talent, and in the labor of so many thousands of men which will be necessary to create and bring into being this great power plant, will be dedicated to the uses of war and, in the final analysis therefore, apparently to destruction and destructive use. But that is only a superficial view. If you examine the situation more closely, you will find first that the creation of this great source of electric power, and through it the awesome force and power resident in the atomic bomb, will exert its greatest influence as a deterrent to the initiation of acts of destruction which always follow acts of aggression. There is sound basis for even greater hopefulness, for constructive hope from these labors and from the expenditure of all this power and energy. If the policy of conciliation toward every nation of good will on the face of the earth; if the policy of helpfulness to all those who are not as fortunately situated as we are as a nation and who are anxious to improve their physical and spiritual lot in this world; if the policy of forebearance coupled with a policy of strength which assures that the forebearance is not misinterpreted for weakness; if this whole policy bears fruit, then some day the diffusion operation in Pike County, Ohio, will come to a standstill.

What of this great power plant whose construction we are initiating? What will happen to it? Will it too come to a standstill? No! It will keep on operating. It will, in that case, become available to provide additional power to hundreds of communities in the great state of Indiana and in surrounding states; to millions of people on the farms, in the great industrial establishments that are scattered over thousands of miles, in the cities and communities of these states, and to millions of people in their homes. They all will be able to receive in greater measure the blessings, the burden-lifting relief that comes and the human enjoyment of living that is made available, from a more abundant and more economic power supply.

Meanwhile we have a great and difficult task ahead of us. We must therefore put our shoulders to the wheel and move on. We must proceed with the job of building this plant as quickly, as economically, as effectively as possible.

Let us hope that it soon will rise and take its place as a mighty weapon for defense; that out of its use as such will come an even greater use, so that it will eventually become a mighty weapon for peace. Let us hope that out of its use, peace, progress, and prosperity will come into being for all the people in this great valley, for all the people in this great country of ours, and for all the people of the world.

Philip Sporn is president of the American Gas and Electric Company, New York, N. Y.

*The Indiana-Kentucky Electric Corporation and its parent company, Ohio Valley Electric Corporation, between them, will own all the generating transmission facilities comprising a total of 2,200,000 kw of generating capacity and 400 miles of 330–345-kv transmission being constructed to supply the requirements of the Atomic Energy Commission at its new diffusion plant operation in Pike County, north of Portsmouth, Ohio. Ohio Valley Electric Corporation is jointly owned and sponsored by 15 electric power companies in the Ohio Valley. Mr. Sporn is president of both companies.

Radio Aids to Navigation

G. L. OTTINGER

For centuries mariners have located their ships on the earth's waters by compass and dead reckoning and here the vagaries of the weather had to be considered. Since electronics came to the navigator's assistance, he has been able to obtain his fixes regardless of weather. Some of these electronic aids are described here.

THE DEVELOPMENT of electronic aids to navigation is relatively new when considered in relationship to the general field of navigation. Through the ages, the science of navigation has progressed step by step from dead reckoning to the adoption of a system of co-ordinates and the invention of the marine chronometer which made possible reasonably accurate methods of celestial position fixing. Navigation was still dependent upon weather conditions over which the mariner had no control. With the advent of electronic aids, this dependency was removed and the navigator is supplied with continuous data under all weather conditions. Experienced mariners, of course, make a practice of using celestial information to corroborate electronic data. The purpose of this article is to examine the radio aids to navigation provided by the Coast Guard.

One of the earliest of the aids is the radio direction finder. In the early 1920's, emphasis was placed on shore-based direction finders to which the ship transmitted radio signals while these stations took simultaneous bearings and transmitted the information by radio to the ship. This system took most control and evaluation away from the mariner and had the further disadvantage of being subject to saturation during periods of heavy use. As the number of shipboard direction finders and shore radio-beacon stations increased, the need for shore-based stations no longer existed. Accordingly, during World War II the use of such stations for navigational purposes was discontinued by the United States.

A number of other quasi-electronic systems, such as leader cable, echo-sounding machine, and hydrophones, enjoyed considerable use in the past. The only remaining one of these devices is the well-known echo-sounding machine.

The mariner fell heir to a number of tailor-made well-tested operational systems developed during the last war, such as loran and radar. Loran as the name implies is a long-range aid to navigation suitable for surface and air use. Radar provides anticollision information and furnishes navigational data in restricted waters and in making landfalls.

A thorough treatment of the various radio aids to navigation is beyond the scope of this article; however, background information will be provided as necessary.

RADIO BEACONS

THE RADIO-BEACON system has a widespread distribution over the United States and its possessions and consists of some 200 stations operating within the frequency band at 285 to 315 kc. Owing to the limited frequency space available, it has been necessary to place these stations on a time-sharing basis in groups of three, with operation during one minute out of three during two 10-minute periods per hour. During periods of poor visibility, the stations operate continuously on their assigned minute. The present radio-frequency space used by radio beacons is saturated and new techniques will have to be evolved if we are to increase the number of stations. In order to reduce interference further, the radiated power output is carefully adjusted for navigation at normal ranges of 10 to 200 miles, and to provide a 50-microvolt-per-meter signal at the maximum advertised range of the station.

A shipboard radio direction finder is an instrument which requires little skill in its use and provides navigational information for the vessel and at the same time is of great assistance in locating distressed vessels at sea. The latter property has been recognized internationally and many classes of vessels are required by law to have a radio direction finder to promote safety of life at sea. This fact in itself insures the continuance of the radio-beacon system.

LORAN

PRIOR TO the war, ocean radio navigational aids depended upon some form of radio direction finding or directional transmissions which are frequently subject to unpredictable vagaries of propagation when used at long distances. The needs of global war necessitated great improvements in range and accuracy of navigational aids and loran was the best available answer to the long-range problem. Loran operates on the principle of measuring the difference in arrival times of accurately synchronized signals sent out by two different transmitting stations of known locations. Since one of the most stable features of radio propagation is the fact that radio signals travel at a constant known speed, a dependable relationship exists between time of travel of radio signals and the distance travelled. This distance measuring technique, plus the use of pulsed signals similar to those used in radar, is the essence of the loran system.

The present loran system is usable over water up to 900 nautical miles in the daytime and 1,500 miles at night. The accuracy of loran fixes compares favorably with good

Full text of conference paper presented at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952.

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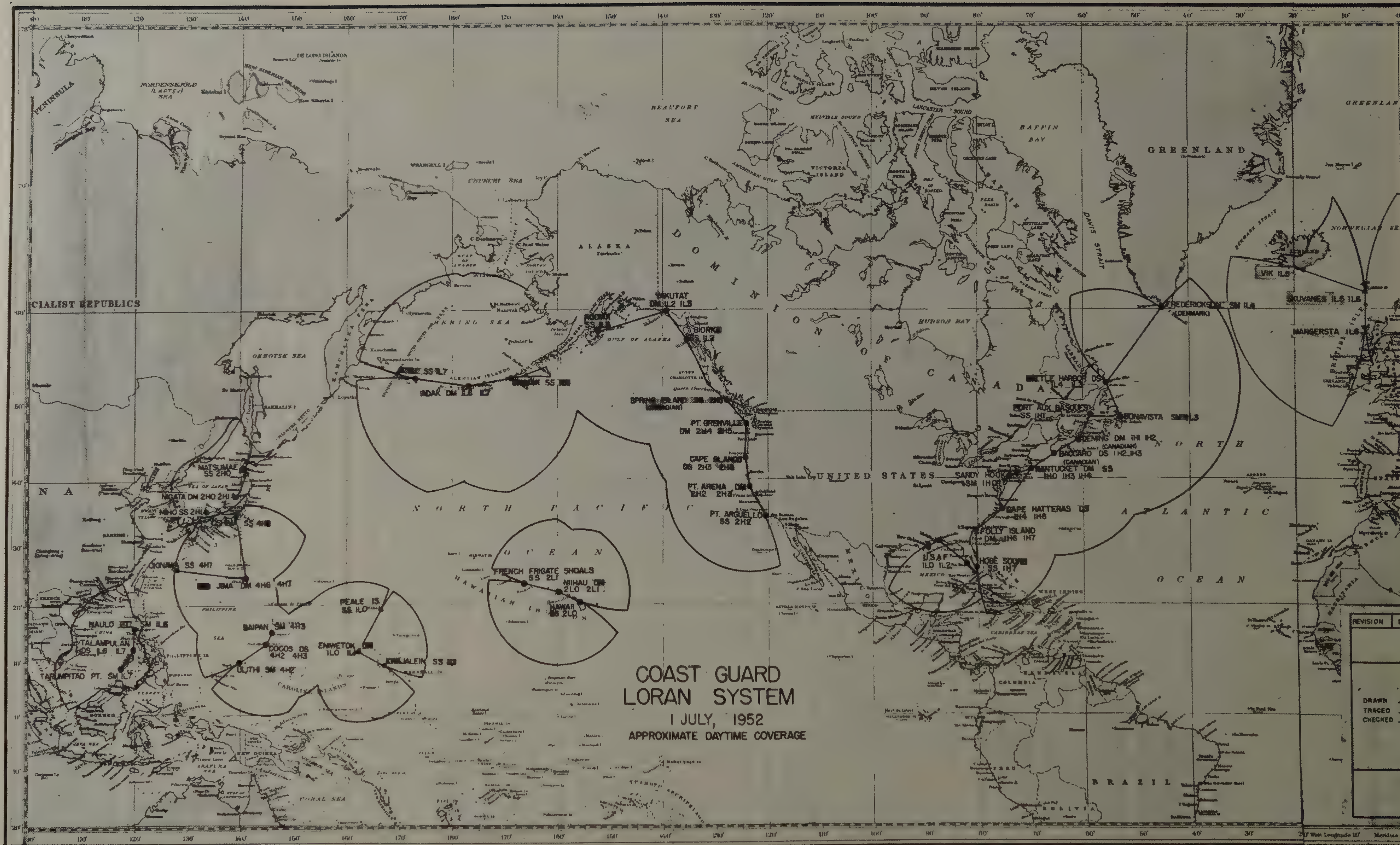


Figure 1. The contour lines indicate the daytime loran service throughout the world. During the night this service is extended to approximately twice the distances as those shown by the 40 stations operated by the United States and seven others operated by Canada, Denmark, Iceland, and the United Kingdom

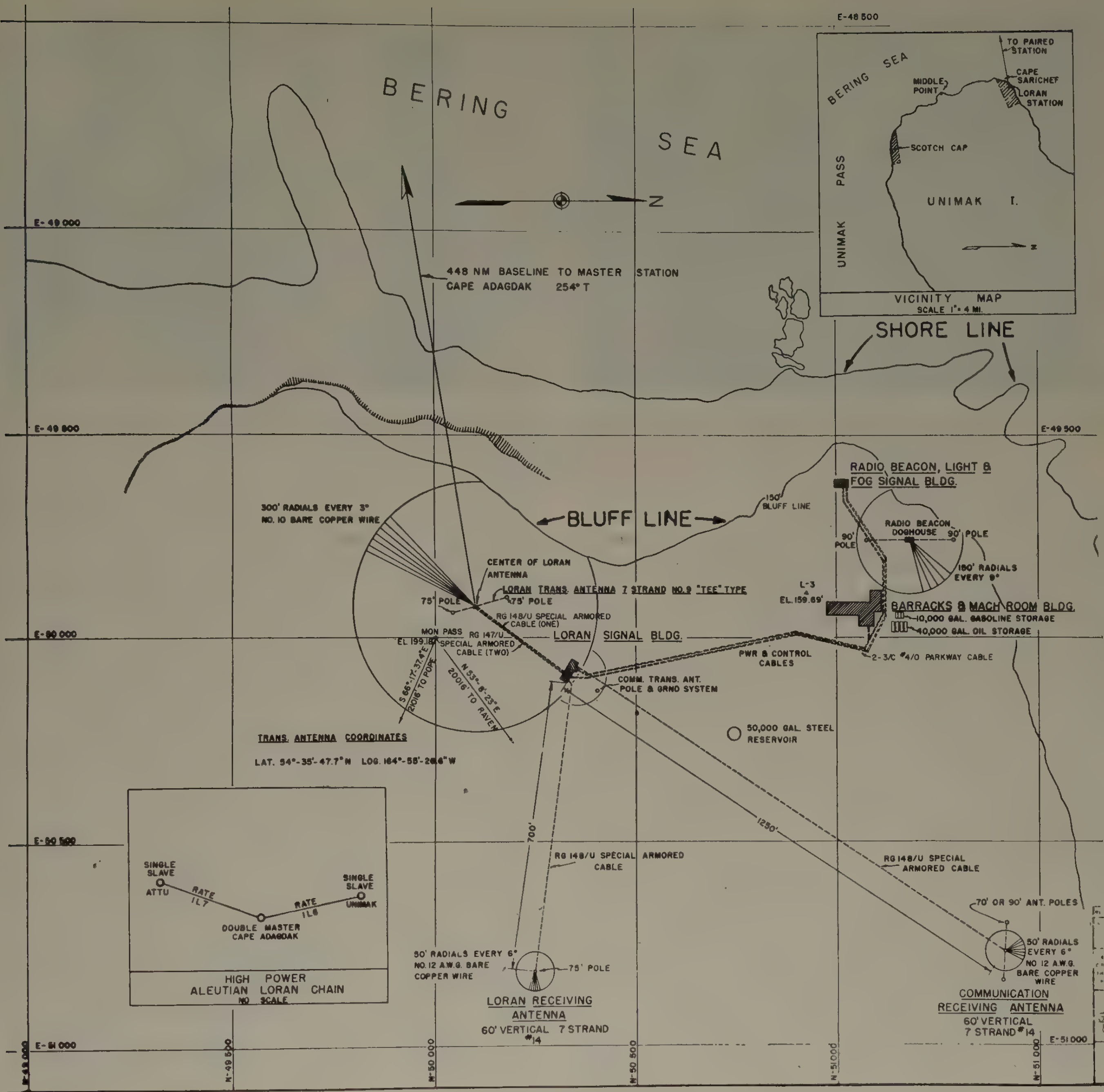


Figure 2. The general plan of the Unimak station in the Aleutian Islands showing the loran station, radio beacon, radiotelephone, lighthouse, and fog signal locations

celestial fixes and they may be obtained in a fraction of the time, under all weather conditions and without mathematical computations. Shipboard equipment is self-contained; all the navigator requires is a loran receiver and the loran chart or tables covering the area.

Figure 1 shows the present loran service throughout the world. This chart outlines the daytime service; contour lines for nighttime service would extend about twice as far offshore. There are 40 stations being operated by the United States and seven other stations by Canada, Denmark, Iceland, and the United Kingdom. Note that coverage exists along the Gulf and Atlantic seaboard and along the greater portion of the North Atlantic steamship route. In the Pacific the routes to the north and to the far east are generally covered.

Let us examine a Coast Guard station that provides a number of types of navigational service for the mariner. Figure 2 is the general plot plan of the Unimak station in the Aleutians which consists of a high-power loran station, a medium-power radio-beacon station, radiotelephone and radiotelegraph, a medium-power light, and a fog signal. The Unimak Loran Station is a slave station synchronizing with the master station located on Adak, 448 miles to the westward. The plan shows the location of all buildings, the deployment of antennas and ground systems, the direction of the paired loran master station, the navigation

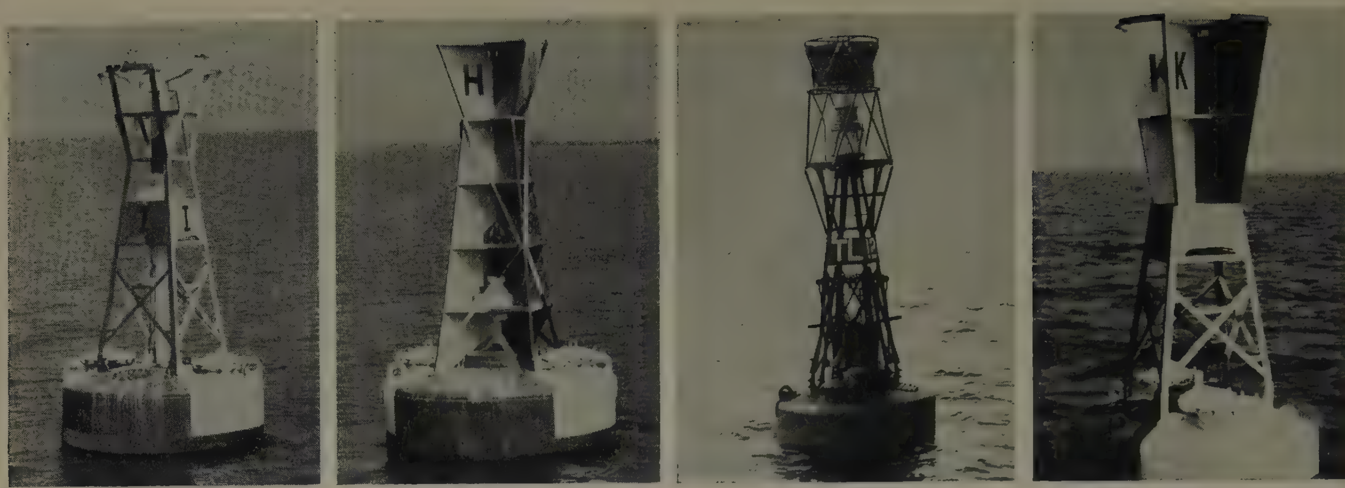


Figure 3. The designs of the various types of buoy reflectors; from left to right, standard 9X38, XRA planes, Type B, and partial XRA

light, and the foghorn. Those who are familiar with Alaska and the Aleutians will also remember that this station is located on one of the loneliest islands in the world and enjoys all types of inclement weather.

Radio-beacon transmitting equipment adjusted for 100-mile coverage is located in the same building with the light and fog signal equipment. One unusual feature is that control and timing equipment is located in the loran signal building so that the one operator on watch can handle all transmissions.

The navigation light is electric powered, of 9,000 candlepower, and has a seaward range of approximately 20 miles under conditions of good visibility. A 2-tone diaphone fog signal with a range of 5 miles is operated from compressed air provided by electric motor-driven air compressors installed in the same building.

Loran equipment is located in the loran signal building and the antennas are shown around it. High-powered loran transmitters at this station have a peak power output of one megawatt. A standard loran station has a peak power of 150 kw and can be converted to high power by the addition of a linear amplifier. Average power outputs of 1,000 watts and 150 watts respectively are obtained, as the duty cycle of loran transmissions is approximately 0.001. Therefore, primary power requirements are very modest and illustrate an important advantage of pulsed systems, particularly at remote and inaccessible locations.

Worthy of further mention are the antenna systems in use here. The megawatt loran transmitting antenna is of the "TEE" configuration with a vertical section 65 feet long with a 71-foot flat top. At the assigned transmitting frequency of 1,950 kc this antenna has a resistance of 28 ohms and a slight positive reactance, which can be readily tuned by a simple network. In order to reduce ground losses to the greatest practicable amount, a ground screen is used of 120 300-foot radials. The question may arise as to why we do not employ vertical antennas as they are particularly efficient with regard to maximizing ground wave coverage. The considerations here are purely practical; in locations where winds frequently rise above 100 miles per hour a tower of sufficient strength is extremely heavy, expensive, hard to transport and erect, and in some locations, is a hazard to aircraft. For installations outside of the continental limits the Coast Guard has standardized on this type of antenna. We have a number of 300-foot, or approximately 5/8-wavelength, vertical antennas in the United States.

The function of the loran receiving antenna is to receive signals from the master station at Adak and to receive its own signal in order to synchronize properly its local transmissions. The early loran stations employed a separate small whip antenna for local signal reception. With this method a system error up to 6 microseconds was found to exist in the synchronization because of the fact that the local and remote signals were handled through a different path; the error was variable, depending upon the tuning of the remote receiving antenna. This was corrected by employing a single receiving antenna. A closer study of the geometry of the system will show that further system errors can also be introduced when the receiving antenna is not exactly on the extension of the baseline from the paired station. For locations other than this the maximum error can be as great as 1 microsecond per 500-foot displacement. Actually these errors are constant, and fixed delay lines could be installed in the proper path to eliminate such differences. Obviously all these difficulties would be eliminated if we were able to receive as well as transmit on a single common antenna and many other advantages in the design and operation of a loran station would result. The main difficulty, however, is in protecting the receiving equipment during the transmission period. What is needed is a transmit-receive tube similar to that used in radar equipment. So far this scheme of operation has not developed much beyond the wishful-thinking stage.

Locating the receiving antenna 1,250 feet away from the loran antenna reduces the local loran signal interference sufficiently for satisfactory communications when a selective communications receiver with a noise limiter is employed. The communications transmitting antenna is of the inclined-vertical Marconi type and is led directly into the transmitter.

Primary power is another interesting feature of loran

stations. In the station under consideration the source of power consists of two slow-speed diesel-driven generators, each providing 93.8 kva of 240-volt 60-cycle 3-phase power. Some difficulty is encountered in providing satisfactory voltage regulation because loran equipment is sensitive to transient fluctuations as well as to normal relatively long-time voltage variations. This is readily understood when you consider that a loran station is controlling the keying of the transmitter to within a fraction of a microsecond. The counters in the timing equipment can jump or lose a count if a momentary voltage variation occurs, and the problem is particularly acute at the Unimak station because of the 20-horsepower air-compressor motor and several smaller 5-horsepower blower motors. The voltage regulators in use are of the silverstat type. Some of the most recent installations employ static excitation and voltage regulators with magnetic amplifiers. Preliminary reports indicate that operational characteristics of power supplies with this type of regulation are greatly improved.

OCEAN STATION VESSELS

In co-operation with a number of foreign countries the United States maintains station ships at various strategic locations in the North Atlantic and North Pacific ocean areas. These stations are primarily manned to provide meteorological observations, navigational aids, communications, and search and rescue services.

Station vessels provide radio-beacon service which enables the transocean craft to establish accurately a line of position in the same manner as with a shore-based beacon. Air and surface search radars are used to furnish radar fixes, as required.

The multiplicity of antennas is probably the most striking aspect noted on the first observation of such vessels. These antennas are used for all frequencies from the very low up through the ultrahigh frequencies.

It is frequently essential to have several communications taking place simultaneously. Therefore, it is required that transmitting antennas be separated as much as practicable from the receiving antennas. In this case, we have made every effort to locate all transmitting antennas forward and receiving antennas aft.

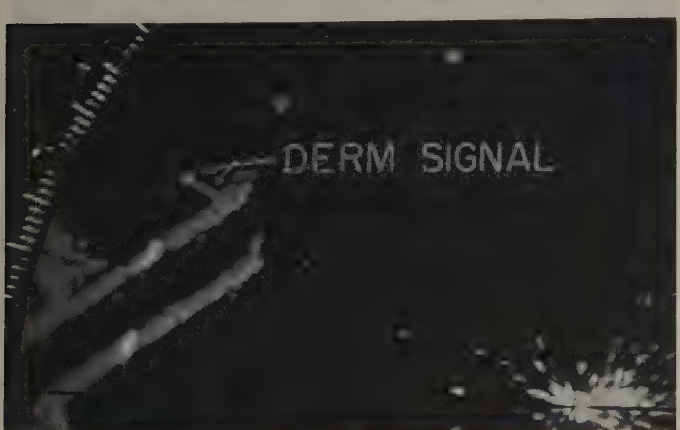


Figure 4. A portion of the plan position indicator scope showing the type of presentation by the DERM, a series of dots following the target pip

Figure 5. An experimental pelorus design for use on both 3- and 10-centimeter signals

Navigational information is centralized in a compartment aft of the bridge known as the Combat Information Center or CIC. Here indeed, is the nerve center of the ship. There is such a myriad of electronic equipment, control equipment, and intercommunication trunks that a highly trained team is needed. In order to facilitate training of personnel manning the CIC, with a minimum of interference to the regular duties of operational ships, we have found it necessary to design special mobile trainers. These trainers contain typical radar equipment, radio direction finders, and loran receivers, plus a target simulator which provides controllable signals to set up operational and navigational problems encountered in the CIC of any Coast Guard vessel.

RADAR AND RADAR AIDS TO NAVIGATION

The role played by radar on board ship is well known and will not be dwelt upon here except to point out that radar-equipped ships still go aground and have collisions in spite of, or perhaps because of, the radar. The situation is still not too black for the radar design engineer, however, for the majority of these casualties are directly due to human failures. Design can minimize this type of failure, but proper training is the only satisfactory solution.

While the resolving power of our present-day radars is good and may be improved slightly by future development, the navigator still finds himself in positions wherein he needs assistance for safe radar navigation. For this purpose both active and passive radar aids have been developed. Active aids generate and transmit a microwave signal which is received by the radar, while passive aids pick up and reradiate the original radar signal. The development and provision of radar aids is considerably complicated by the fact that commercial shipboard radars operate in two frequency bands, namely, 3,000 and 9,000 megacycles.

The Coast Guard is providing radar beacons on an experimental basis at a few selected locations in order to evaluate the practicality and need for such beacons.

These beacons are of the radar marker type commonly referred to as RAMARK and function in about the same way as a radio-beacon transmitter. In this case the beacon transmits continuously a few watts of microwave power on the radar beacon frequencies. By depressing a button to tune his radar receiver the navigator observes a pencil of light on his radar scope on the bearing of the beacon. Little data have been received beyond observations made on Coast Guard vessels, mainly because of the additional cost of modifying the shipboard radar for beacon reception.

In considering passive radar aids, radar reflectors have proved to be of great assistance for increasing the reflecting properties of buoys. Their low cost, simplicity, reliability, and freedom from power requirements are added benefits.

The Coast Guard has been studying the design and collecting field data of such reflectors for some time. Figure 3 shows a variety of reflector buoy designs. A standard 9X38 lighted bell or whistle buoy less the lighting mechanism has been used as the foundation and the structure has been modified to include various types of reflectors. The test vessel was fitted with both 3- and 10-centimeter radars of commercial design, with the antennas being located 53 and 58 feet, respectively, above the water. A blip per scan (b/s) ratio method of evaluation is used. For example, if a target is observed during every rotation of the antenna the ratio is unity, if the target is seen 50 times out of 100 rotations the ratio is 0.5. The latter figure is considered to be the ratio below which a target becomes unusable for radar. Table I lists the results attained.

Table I

Buoy Designation	Range in Miles For 1.00 B/S Ratio 3 CM	For 1.00 B/S Ratio 10 CM	For 0.5 B/S Ratio 3 CM	For 0.5 B/S Ratio 10 CM
"A" Std. 9X38	2.4	2.1	4.4	3.0
"B" XRA	5.0	3.2	9.7	6.2
"C" Type B	9.7	4.0	11.4	6.1
"D" partial XRA	5.3	3.7	8.8	4.7

The data in Table I were obtained in Chesapeake Bay under smooth weather conditions. It is to be noted that all reflectors improve the radar detectability range by about 100 per cent or more. As a practical matter the Type *D* buoy is rugged, easy to handle, and costs about 1 per cent more than the total cost of the present operational buoys. The Type *B*, which is the most effective reflector, is not as rugged and increases the over-all cost of the buoys by about 10 per cent. It would appear that the Type *B* could be justified only in very important locations. As the present stock of lighted buoys is expended they will be replaced with the new design incorporating the features of the Type *D* reflector.

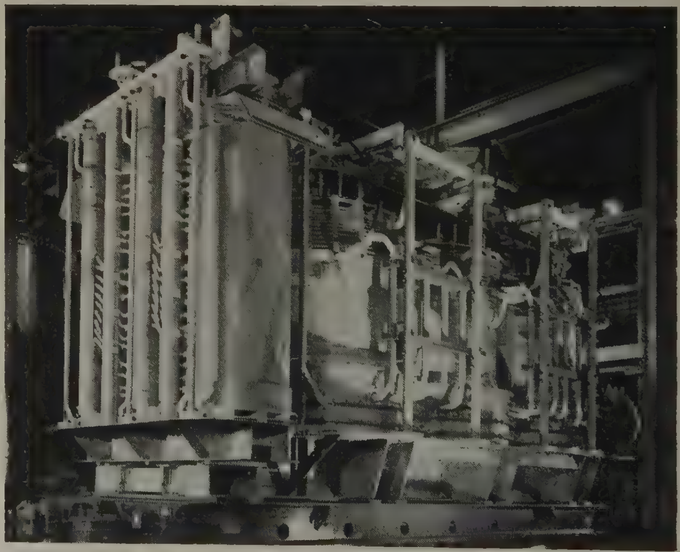
A second type of passive reflector called the DERM or delayed echo radar marker, now in the development stage, is merely an echo box with an antenna. The DERM receives the radar signal, holds it for a fraction of a microsecond, then sends it back. On the radar indicator the presentation is a series of small dots behind the target as illustrated in Figure 4.

Another radar aid showing promise of future application is the radar pelorus or microwave direction finder conceived several years ago by the National Research Council of Canada and recently modified by the Coast Guard. This equipment consists of a small directional antenna, similar to a radar antenna, a crystal detector, simple amplifier, and headphone or meter indicator, and is designed to take bearings on microwave signals transmitted by radars and RAMARKs. Figure 5 illustrates an experimental pelorus design for use on both 3- and 10-centimeter signals.

CONCLUSION

This article has briefly reviewed the status of the marine electronic aids to navigation. The picture for the future of such aids will probably look like this: The use of radar for short-range navigation will increase as will the use of both passive and active devices to supplement the information obtained from radar. Radio beacons for medium distance will be with us for many years to come, although we cannot expect that the system will be greatly expanded until the limitations of available frequencies has been overcome or new techniques developed. Loran is a basically sound system and will remain for some time as the main long-distance aid to navigation. Expansion of the system is continuing and will be paralleled by improvement in system accuracy and the production of new and simpler loran receivers.

Largest Autotransformer



Interior is shown of the world's largest autotransformer built for Illinois Power Company by General Electric. Weighing more than 200 tons and measuring more than 30 feet long, 17 feet wide, and 22 feet high, the autotransformer contains 42,000 pounds of copper and 103,000 pounds of silicon steel. The completed autotransformer will contain 19,000 gallons of special insulating oil. Pictured is unit's core of silicon steel and copper winding coils

Ground Relaying of Generators in Unit Connection

E. T. B. GROSS
FELLOW AIEE

A-C GENERATORS in modern power plants usually are operated in unit connection directly on high-voltage bus bars, that is, alternator and transformer form one unit so that the circuit breaker at generator voltage is eliminated. A preferred method of ground protection for such units has been indirect high-resistance neutral grounding by connecting the primary winding of a distribution transformer between generator neutral and ground, and by loading the secondary of this transformer with a resistance of such magnitude that the resulting primary ground current for a solid ground fault at machine terminals becomes 10 to 20 amperes. This grounding method was first suggested[1] in this country by L. F. Hunt as a means of minimizing fault damage within generators. The sensitivity of this scheme of protection depends on the lowest permissible pickup current of a relay activated by the current through the resistance. This pickup current indicates the parts of the machine windings which are protected. The straight line in Figure 1 shows that the assumed relay setting would lead to relay operation for faults anywhere between machine terminal (100) and location *a*, whereas ground faults between the neutral (0) and *a* would lie in the unprotected or dead zone.

A considerably smaller unprotected zone, near the generator neutral, can be produced if the constant resistance is replaced by a nonlinear resistance as indicated in Figure 1, following a suggestion made by W. Buetow. The same relay pickup will now shift the critical location in the winding from *a* to *b;* the latter being much nearer to the neutral. The dead zone is reduced from *a* 0 to *b* 0.

Practical experience has shown that faults may occur anywhere in the machine winding since they are often due to causes other than electrical stresses; faults are known to have been found at 30 per cent from and even much nearer to the neutral. Therefore, it is desirable to eliminate the dead zone and to improve the protective scheme still further. Following R. Pohl, this can be done by permanently introducing a voltage between machine neutral and ground of such magnitude that relay pickup will take place for ground faults anywhere in the windings. Two alternative schemes for obtaining complete ground protection are shown in Figure 2. A small single-phase

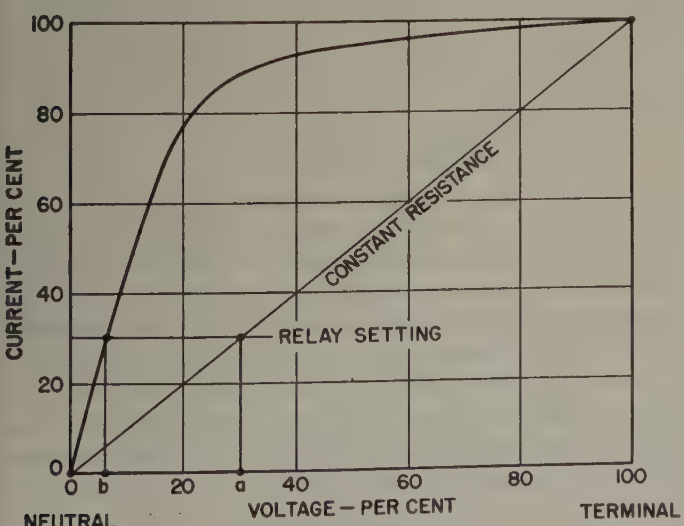


Figure 1. Characteristic of constant and nonlinear resistance R

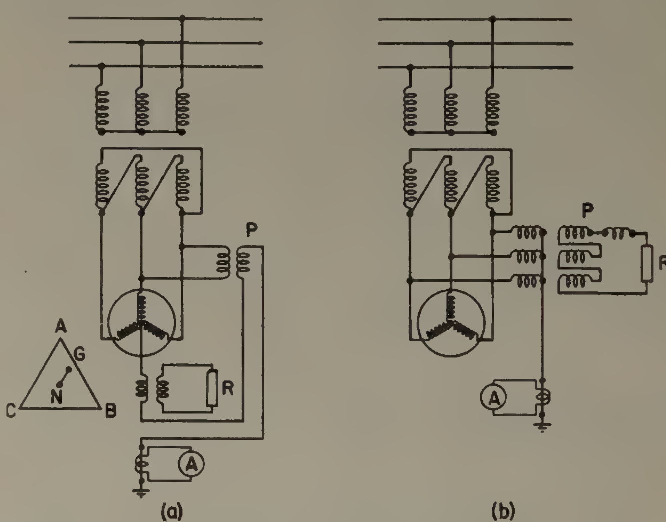


Figure 2. Complete protection using Pohl's transformer

A—Grounding of the generator neutral

B—Grounding through a 3-phase displacement transformer P with ballast tubes R on the secondary

distribution transformer *P*, connected line-to-line, is used to displace ground from *N* to *G* in Figure 2*A*, whereas a 3-phase grounding transformer is used in Figure 2*B* to produce a displacement voltage which is in phase with a phase to neutral voltage. In both cases, nonlinear resistances *R* are connected in the secondaries and the sensitivity of the ground relay *A* is so selected that it will not respond to circulating currents of triple frequency. These and similar schemes have been in successful operation abroad for 25 years and many generators are so protected.

REFERENCE

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Digest of paper **51-371,** "Sensitive Ground Relaying of A-C Generators," recommended by the AIEE Committee on Relays and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951, and for representation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Computers—Past, Present, and Future

W. H. MacWILLIAMS, JR.
ASSOCIATE MEMBER AIEE

This article deals with the historical development of computers. It also discusses current problems and indicates future structural and functional computer trends which will help to free man from burdensome calculations and increase his material wealth while permitting him more time for pursuits not directly concerned with earning a living.

COMPUTING devices have been a vital factor in the past century's revolutionary increase in the level of complexity of practical engineering. This article reviews the progress made in computers, that is, computing devices, in the past century, discusses some of the principal problems confronting computer designers and users today, and speculates on the future course of the computer art.

A computer is defined here as a device which accepts quantitative information, may arrange it and perform mathematical and logical operations on it, and makes available the resulting quantitative information as an output. This definition is intentionally broad. It includes devices from a slide rule to a differential analyzer, and from a desk calculator to a telephone exchange and a large-scale digital computer. The computer is thus an information-processing device. The arranging of the input information is frequently as important as the other functions.

Computers are composed of two types of components, digital and analogue. A given computer may be largely digital, largely analogue, or a mixture of both. Analogue-digital converters are used to change information from one form into the other.

In digital computation, the variables are allowed to have only a discrete number of values. A conventional desk calculator is of this type: it may represent a million or a billion different values of a quantity, but the number is bounded. The smallest recognizable difference is fixed beforehand, and is independent of adjustments as long as the computer is working. Dice are also digital components. In analogue computation the array of apparatus is so chosen that the mathematical relations it obeys are the same as those describing the problem to be solved, except for scale factors; the array is the analogue of the problem. The simplest analogue computer is the slide rule, where the distance between the graduations representing two numbers is proportional to the difference between the logarithms of the numbers. The automobile speedometer is another. The variables are essentially continuous, but nevertheless subject to errors. The precision of an analogue component is limited by construction accuracies, but the precision of a digital component can be increased by adding more places, with an increase in size and complexity. In analogue work it is easy to achieve a precision of 10^{-3}, harder to get 10^{-4}, and 10^{-5} is obtainable only under highly restricted conditions; the precision of practical digital machines starts at something like 10^{-6}, and one large computer has a precision of 10^{-23}. An analogue component may represent a very complex law, however, whereas the digital component is limited to counting.

It is useful to make a special classification of computer problems which have time as a parameter, and in which the value of this time is importantly related to the clock time at which results appear. When the time represented in a computer is the same as clock time, the computer operates on a one-to-one time scale; it is conventional to say that the computer is operating in real time. When the time representation may be other than one-to-one, a choice in the time scale is possible, and the computer is said to be operating in arbitrary time. The arbitrary time scale is usually slower than real time, but it well may be faster.

Typical real-time computer applications are the control of a chemical process, of a machine tool, and of air traffic to and from an airport. Most arbitrary time problems are numerical calculations, such as obtaining the equilibrium temperature distribution in a turbine casing, or determining the resonant frequencies of a crankshaft. Although it may be important to complete these latter calculations soon, the instant at which a result is obtained is not critical.

COMPUTERS A CENTURY AGO

IN 1852 the computing devices in use were exclusively mechanical. The only analogue computers in use were the planimeter, which dates from around 1814, and the slide rule, which is some 200 years older. The abacus had been in use for many centuries. The "desk calculator" of the day represented only minor improvement over the adding machine invented by Blaise Pascal in 1642. Pascal made decimal machines and also a model adapted to the coinage of the time, to assist his father in checking accounts. With one livre equalling 20 sous, and a sou equalling 12 deniers, it is certainly plausible that difficulties with monetary computations far outweighed problems of addition and subtraction in the decimal system. The Pascal

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machine was modified in 1694 by G. W. Leibnitz to facilitate multiplication by repeated addition, and in 1820 improved further by C. X. Thomas, who eventually manufactured over 1,500 units of his model. Even this improved computer was still big and clumsy—a 6-place Thomas machine covered an area of 9 by 30 inches.

In contrast to the limited state of development of commercially available computers, the concept of a digital computing machine in the most general sense of the term had already been well worked out by Charles Babbage.[1] He was distressed by the tremendous labor of computing function tables (largely for astronomical calculations) and by the fact that both the tables and their errata were full of errors which were eliminated only by discovering inconsistencies late in computations. In 1822 Babbage proposed that the British government sponsor the design and construction of an elaborate digital difference-equation solver capable of handling numbers of 20 decimal digits and differences up to the sixth order, which he called a Difference Engine. He already had built a model to demonstrate the principle; it permitted the solution of difference equations whose second differences were constant, with arbitrary initial conditions, for second differences up to five decimal digits. It was recognized that many errors were introduced into function tables through faulty transcription of data, and Babbage proposed that in his machine the output data be "transferred through a set of levers and come to a collection of steel punches, which would stamp the number on a copper engraver's plate." Babbage estimated that the completed machine would weigh about 2 tons. In a burst of enthusiasm which sounds quite current, Babbage estimated that the job would require 2 to 3 years and would cost from £3,000 to £5,000.

The British government agreed to his proposal, and design and construction were started. Ten years later, after a large amount of background work developing new mechanical methods to permit construction of such an elaborate device, Babbage found himself with the machine near completion, but unfortunately construction was halted at this time, owing to a disagreement between Babbage and the chief mechanic. By then the government had spent about £17,000 and in addition Babbage had invested about £6,000 of his own money. The British government advanced no further funds, and after 8 years of negotiation, finally decided to drop the project. Although isolated parts of the machine had been assembled, the machine as a whole was never completed.

In the meantime Babbage had conceived the idea of a much more general computer which he called the Analytical Engine. The general characteristics of the Analytical Engine anticipate very well the characteristics of the present large electronic digital computers, except that it was much slower. Babbage intended that it use 50-decimal-digit numbers and a memory capacity of 1,000 numbers. The central mechanical feature in his machine was the system of cards perfected by Jacquard in power looms. This forerunner of the modern punched card was used to control elaborate patterns woven into cloth by threads of many colors. In the words of Lady Lovelace, a friend of Babbage, "the Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves."[2] The machine was intended to use the Jacquard cards in two different ways: "operation" cards gave orders to the "mill" which was the arithmetic element of the device; and "variable" cards specified the locations in the "store" of the two pieces of input data and the result of the computation. In the present parlance, the machine was a "3-address" computer. Eloquent passages in Babbage's writings show his full realization of the ability of his machine to modify its own program in accordance with the results of the computations; he was fully aware of the possibility of using the same language for numbers or instructions. It was planned by Babbage that his arithmetic element be capable of addition, subtraction, multiplication, and division; he estimated that it would multiply two 50-digit numbers in 3 minutes, a time considered phenomenal in those days. The input was to have been by Jacquard cards, and Babbage planned that the output facilities of the Analytical Engine include a device for printing one or two copies of its results directly on paper, a means for making stereotype molds for printing additional copies, and finally, facilities for punching its output data on cards to have them available for further computation by the machine.

Unfortunately, Babbage was never able to get financial support for the Analytical Engine, and all he could do was to work on the plans. Nevertheless, it is remarkable that only in the last decade have we been able to translate Babbage's dreams into equipment.

PROGRESS IN COMPUTERS DURING THE PAST CENTURY

The expansion in the design and use of computing devices in the period from 1852 to 1952 has been great. A summary of the progress in this century is very nearly a summary of the entire past history of the art. The general development pattern was first to make computers faster, bigger, and more versatile, still using mechanical means, and then starting in the 1920's, gradually to replace the mechanical means with electrical means—relays, tubes, crystal diodes, and transistors—with further increases in size and complexity as a result of the improved speed and flexibility of electrical components.

Initially, activity was concentrated in the improvement of small mechanical digital computers. Single-operation multiplication was introduced by Leon Bollée in 1888. The first successful key-driven adding machine was the Comptometer which was developed in 1887 by D. E. Felt, although a simple key-driven adding machine had been patented in 1850. The Comptometer later introduced means to minimize human errors, including a key-guard to prevent striking more than one key with the same finger; another feature made the keyboard essentially self-checking, since the machine would not operate if a key was not fully depressed. The first printing adding machine was made in 1872, and in 1889 and 1892 the first practical adding and listing machines were made. Further developments in integrating these mechanical computers into business operations followed, including calculator-cash-registers. Electric-drive motors were added in the 1910's and 1920's, leading to more complex control circuits, since control

switches could be operated by keys or light portions of the internal mechanism; these changes led to more useful machines. The computers grew into complex billing machines, which included the operation of transferring the results of computations to customers' balance sheets. The Jacquard card which Babbage had suggested earlier was reintroduced by Hollerith in an automatic machine for sorting, analyzing, and tabulating the data of the United States Census, starting with that of 1890. This machine used electric circuits to sense holes in the punched cards, by having metal brushes make contacts through the holes. Punched card equipment has been developed extensively by the International Business Machines Corporation for manipulating business data, and the availability of this equipment has been an important factor in the development of present digital computers.

Early analogue computer development was also along mechanical lines. The planimeter underwent successive improvements, and other types of integrators were developed. The ball-and-disk integrator was invented in 1876 by James Thomson, and in the same year his brother, Lord Kelvin, combined a number of these into a harmonic analyzer, which would determine 11 Fourier coefficients from a curve drawn on a sheet of paper. A harmonic synthesizer already had been designed by Lord Kelvin, in 1872, to predict tides. It could predict a year's tides for a given locality in about 4 hours. The combination of a number of integrators into a general-purpose analyzer was suggested by Lord Kelvin, but the mechanical details were beyond the capabilities of the time and no servomechanism was at hand.

For obvious reasons, military designers have developed and used analogue computing techniques for the control of gunfire against moving targets. It appears that the earliest work of this nature was started during World War I for application to antiaircraft fire control, extending even to rudimentary electrical computing techniques. After the war, Hannibal Ford used his invention of a means for considerably increasing the torque output of the ball-and-disk integrator to make a naval gunfire computer which was essentially a mechanical differential analyzer; and Major Wilson of the Army Ordnance Department developed the first of a series of Army antiaircraft computers using mechanical analogue techniques. The first large differential analyzer was made by Vannevar Bush in 1925, at the Massachusetts Institute of Technology. It was mechanical throughout, including the string-type servomechanisms. A number of models similar to this have been made. In addition, very large numbers of simple special-purpose mechanical analogue computers have been made and are in active use.

The first electric analogue computers were essentially measuring apparatus, such as the various bridges. Numerous analogue schemes have been used for solving Laplace's equation; for example, those using poorly conducting liquids and potential probes. The first large computers apparently were those used for investigating load distribution in complex electric power networks. These network calculators[3] started out as simple d-c devices using variable resistances for determining steady-state conditions, and progressed gradually to elaborate devices for determining steady-state and/or transient performance of large power systems, taking into account the effects of both resistive and reactive characteristics of lines and loads. A recent steady-state network analyzer has 20 generators, 152 lines, and 56 loads.

Adoption in the 1930's of servo methods of solution of equations using potentiometers and resolvers gave further impetus to electrical analogue computation. The introduction of the feedback amplifier into analogue computation has resulted in considerably improved accuracy and versatility. A number of simple differential analyzers incorporating these principles and giving solutions as plotted curves are on the market today. The components are also available, so that a user may assemble his own apparatus to fit his needs. Solvers of simultaneous algebraic equations can be bought. Small special-purpose computers are being used for process control and a bewildering variety of other computing purposes.

The field of electrical and electronic digital computation has been spectacularly active. An early development was that of the punched card techniques already mentioned. This development had far-reaching effects on the handling of data preparatory to numerical calculation. Another foundation stone was the development at about the same time of relay apparatus for controlling complex telephone switching networks and of the relay apparatus which replaced the early mechanical railway switching equipment. These equipments showed that it was possible to perform complicated logical operations with relays and to obtain reliable operation of complex relay networks by using self-checking techniques. In the telephone system the techniques which gave reliability—alternate routes, second trial, and self-checking—grew as the control became more centralized. These techniques came in with the change from step-by-step systems, which interpret a subscriber's dial pulses as switching control signals, to panel and crossbar systems, which work out their own switching paths, considering the dial pulses only as identifying the called party. In 1938 George Stibitz developed at the Bell Telephone Laboratories a simple relay computer for adding, subtracting, multiplying, or dividing two complex numbers; the computer was also capable of remote control. In subsequent relay computers a self-checking code was introduced into number transmission, which would signal any error due to a single malfunctioning relay contact.

The three pioneer efforts in the rise of relay and electronic computers in the past decade have been the Harvard Mark I Calculator, a 23-decimal-digit relay machine jointly developed by the International Business Machines Company and Harvard University; the ENIAC (Electronic Numerical Integrator and Calculator), a computer developed by the University of Pennsylvania for generating trajectories of projectiles and bombs, which contains some 18,000 vacuum tubes; and a series of further Bell Telephone Laboratories computers culminating in the Model 6.

Following the close of the war a number of large-scale electronic digital computers were started. The total amount of money invested and the optimism in which the

development of these large and complicated machines was undertaken is probably unique in recent engineering experience. Most of the machines undertaken immediately after the war have now been completed and are operating, but operation has usually been much delayed over designers' estimates and the development costs have been correspondingly high. The principal way in which these machines differ from the early machines is in the kind of memory used. Magnetic drums, magnetic tapes, and electrostatic storage tubes have been used to provide high capacity or short access time; no means has yet proved satisfactory for getting both. The result of a great deal of operating difficulty has been a realization that reliability of circuit operation is a vital feature for the success of a computer and that there is no short cut to it.

A new group of large digital machines is now being developed, based on experience with the old ones. Additional memory devices are now becoming available, including ferroelectric materials and magnetic cores. The transistor is another important new component.

A recent step in the integration of relay computers into business operations has been the development of automatic message accounting, for incorporation into the telephone switching system. With this equipment the telephone switching apparatus not only makes a subscriber's connections, but also computes his charges and prints his bill.

A striking development has been the appearance of a number of small-scale commercial computers of the punched-card and magnetic drum varieties. These computers are fast compared to desk calculators, and can still be operated practically as desk-type machines. They are of outstanding importance because they have the potentiality of bringing the benefits of high-speed computation to large numbers of users who cannot afford the large costs of the big electronic digital machines. A large machine can easily cost a million dollars, and an equal sum can be spent on a year's operation if the machine is heavily used. The small machines cost around $50,000 and are thus applicable on a much broader base.

The speeds of digital machines have increased about a millionfold since Babbage's plan; from one operation per minute to some 20,000 operations per second.

PRESENT COMPUTER PROBLEMS AND TRENDS

Analogue and Digital Computers. At the present state of the art, analogue and digital techniques supplement each other well. The analogue machines are usually simpler, and for many problems their precision is greater than the accuracy of the input data. Analogue machines are best for problems where engineering accuracy is sufficient; it is preferable that the system of equations be predetermined, although it may be very elaborate. The digital machines have great flexibility and permit much more extensive use of iterative solutions and of nonlinear mathematics. The digital computer is preferable where great accuracy is required, either intrinsically or to minimize roundoff errors in iterative calculations. It is also good where the problem setup must be changed radically in the course of the problem, or where sorting and other manipulations of data are necessary. A powerful combination is a simple analogue computer to permit a problem to be understood and a digital computer for detailed investigation of the areas of a problem that need it. The development of simple methods of analogue-digital conversion is tending to make computers combine analogue and digital elements.

Analogue Computers. The techniques of analogue computation are well understood, and they are very widely used in computers covering a great range of complexity; there are few problems. They are simple enough that a great many are built to solve special problems. The availability of flexible general-purpose differential analyzers like the REAC has made possible a major advance in the quality of engineering design. To cite a particular example, the guided missile art owes much of its rapid progress to the availability of such computers. The Typhoon computer, perhaps the most complex analogue computer so far described in the literature, is able to represent a guided missile in flight in real time to an accuracy and completeness which Ridenour[4] estimates could only be duplicated digitally if present machines were 20 times faster. Analogue computer accuracies probably will continue to improve and sizes to decrease, and analogue techniques will be used even more widely.

Digital Computers. The techniques of digital computation are still new enough to present many unsolved problems. An excellent detailed summary of the unsolved problems of large digital computers has been given by Forrester.[5]

One of the difficulties with the field is that it is so new that the same words mean different things to different people. Successful operation of complicated computers is so recent that well-thought-out standards of performance and reliability have not been arrived at as yet. This omission is in the process of being rectified, however, and an AIEE subcommittee has been set up to consider this particular problem.

The problem of reliability is exceedingly important, particularly in real-time computers, whether for civil or military applications. The power of modern digital computers in handling enormous numbers of individual computations to arrive at a final result is matched by the critical dependence of the result on accurate computations at every step of the way. There are two ways to get reliability: the component approach, by building the equipment so well that it operates without errors; and the system approach, of designing the computer with self-checking features so that it recognizes when it has made an error and then goes back and recomputes the problem, meanwhile retaining the partial results that it had accumulated before the error was made. Actually only a combination of these two attacks will produce the proper results. If the errors are sufficiently infrequent and uncorrelated, self-checking and recomputation of partial results can be tolerated because they will not produce too great a delay. For real-time applications it is essential that a computer work at 100 per cent of its normal accuracy for something like 99 per cent of its scheduled time, and for the remaining 1 per cent of the time that it is in trouble, it should give

results of near-normal accuracy. The computer should be like a pianist who is accompanying singers—he should play well most of the time; a few wrong notes are permissible, but he must not lose his place and stop altogether. The emphasis on maintaining the tempo in a real-time computation is easier to meet if the computer has enough speed to permit repeating a computation if necessary without losing step, and enough equipment to permit use of alternate paths. It is essential that methods be developed for tube, transistor, and diode circuits which have the reliability that already has been obtained with relay circuitry in telephone switching systems. This problem is a long way from solution.

Another important difficulty arises from the disparity between the abilities of a machine and of the operators who must run it. To use a recent stenographic error, the computer should be a "deferential analyzer." The machine must work in minute detail, and handle large amounts of data. At the level of the arithmetic unit, the machine is exceedingly fast but likewise so simple-minded that it must be instructed in great detail. As Claude Shannon has expressed it, "A digital computer must be instructed in words of one microsyllable." The problem is roughly that of being able to give enough instructions to a computress operating a desk calculator to keep her busy for a year, and to take care of all conceivable contingencies. On the other hand, the human being who is introducing the problem is much slower, has a limited capacity for storing data, but has the ability to draw unprogrammed conclusions from data presented to him. It follows that the man should use the machine itself to expand his concisely expressed ideas to the enormous detail required for control of the arithmetic element. This programming problem has been approached in two ways. The first is by accumulating a library of subroutines, and drawing on this library freely when making up the program for a new problem. This approach is helped by constructing codes in an invariant form, so that they may be adapted to the needs of a particular program by the introduction of arbitrary constants specifying the location of appropriate storage registers. The second method for alleviating the programming difficulty is that provided in the Bell Telephone Laboratories' Model *6* computer (although of course it also can use the first). This method consists in having a number of routines and subroutines semipermanently wired into the machine. The routines exist in several different levels of intelligence. The programmer only works with the top level, and the other levels are called into action by the machine wiring. A single instruction issued by the programmer, such as *A13*, may involve as many as 4,000 separate operations inside the computer. The effect of this principle is to permit the operator to regard the upper program level in the machine as the machine's top-sergeant, and to take for granted that this level will take care of further communications within the different echelons in the machine until the calculation is satisfactorily carried out.

Another way in which the difficulty of communicating between the man and the machine arises is in the presentation of output results. It should be possible for the machine to go through a process of data compression and summarization to put the vast amount of data from the arithmetic element into a form which a human being can grasp readily and act on, such as plotted curves or typed instructions, rather than just as a very large array of typewritten numbers.

A less serious difficulty is presented by data reduction problems, where a large amount of input data is obtained in a form not directly usable by the computer, such as on film. It is clear that analogue-to-digital conversion should be done before the data are recorded, and that the recording medium should be suitable for direct input to the computer.

A further means for improving the use of high computing speeds is to increase considerably the amount of memory available at high and intermediate access speeds.

COMPUTERS IN THE FUTURE

Numerical Calculation. As Bush has pointed out, "there will always be plenty of things to compute in the detailed affairs of millions of people doing complicated things." It is easy to say that expanding activity will continue for both analogue and digital computation. The most apparent technical trends are decreased size as a result of miniaturization of components (including an all-diode-and-transistor digital computer), increased accuracy of analogue computers, increased speeds of both digital and analogue computers, and improved communication between men and computers.

In the electronic digital computers in particular, we have not yet learned to take full advantage of the high operating speeds of the arithmetic elements. The central problem for the immediate future is to make effective use of this high potential computing speed.

As reliability and ease of operation improve, and computer speeds increase, the machines probably will turn to more complex problems. The political economy already has been the subject of investigation,[6] and no doubt it will be much more so. Game theory techniques should be applied more broadly, particularly to business operations.

Continued mathematical research should result in improved understanding of the behavior of roundoff errors, and of the convergence of the solution of a system of difference equations to the solution of the system of differential equations which represent the original problem.

Applications Not Specifically Numerical Calculation. The large memories existing and under development afford application to many other problems. Prominent among these are inventory control and ticket reservation[7] and sale. These problems need a large high-speed memory, but an intermediate means is desirable for going between a high-speed memory of limited capacity and a lower-speed memory of much larger capacity. Access times between a tenth and a hundredth of a second may be very useful. An interesting new intermediate-access-speed memory is Rabinow's "notched-disk memory."[8]

A primary application in which information handling is important is that of library service. Information is being accumulated far faster than it is being read, and the

lays in which a person could consider himself fully con- versant with the developments in even a single field have ong since passed. Specialized work is essential for progress, but it is equally essential to make it readily available. With a large-capacity memory, the use of ligital computation in a library is quite attractive.[9] The American Chemical Society has pioneered in this field. Looking slightly further ahead, the memory means being leveloped for digital computation should be very useful n assembling the trails of information demanded by a levice such as Bush's "Nemex,"[10] a hypothetical machine or helping one assemble information from a library.

An early application of a digital technique to process control is Jacquard's looms. Other applications have been investigated recently, including automatic milling machines. Complicated chemical processes, which have ong been the subject of analogue computer control, seem ripe for application of the techniques of digital computa- ion, in order to incorporate more flexible programming.

An important type of process control is that in which he computer program is not completely available in predetermined form, but must be supplemented during he process by the judgment of a human being based on ntermediate results of the computations. In some applica- ions, such use of a machine by a man may result in a program which can then be recorded and put permanently nto a special-purpose computer. In other applications nowever, it is desirable to retain indefinitely the man's privilege of modifying the instructions to the machine as he problem progresses. It is clear of course, that the machine must be capable of putting its results into a form easy for the man to comprehend, and of accepting and utilizing instruction modifications on the intelligence level at which a human being operates.

Use of digital machines for such purposes as language ranslation will undoubtedly be developed, but in a some- what modified form from the type of translation done by human beings. However, to use existing languages di- ectly would require going to fantastic lengths. It may be simpler to coin a new language which might be a sort of basic English, with a greatly decreased redundancy nd made to simplify the transition between the written nd spoken language. Two important results of such a ongue would be the possibility of using the language to ontrol a machine directly, and the possibility of going lirectly from human speech to a written record without using human beings as intermediaries.

These are only a few of the many possibilities which uggest themselves. So far as numerical computing is oncerned, it is appropriate to turn again to Babbage's ime, and quote L. F. Menabrea, a French military engi- eer who made a detailed study of the Analytical Engine:

. . . who can foresee the consequences of such an in- ention? In truth, how many precious observations emain practically barren for the progress of the sciences, ecause there are not powers sufficient for computing the esults! And what discouragement does the prospective f a long and arid computation cast into the mind of a an of genius, who demands time exclusively for medita- ion, and who beholds it snatched from him by the material routine of operations! Yet, it is by the laborious route of analysis that he must reach truth; but he cannot pursue this unless guided by numbers; for without numbers it is not given us to raise the veil which envelops the mysteries of nature.[11]

SUMMARY

What are the results of the revolution in the computing ability of machines? A century ago, Babbage's objective was to use the speed and accuracy of a machine to free men from the drudgery of detailed numerical analysis, so that they could apply their minds to the *results* of analyses. Much progress has been made in attaining this objective, but the increased power of computing machines makes it even more essential to simplify the communications between men and their machines.

Engineering design procedures have been radically improved by the advances in computer ability and the availability of these advances in commercial machines. Computers have slashed the time and expense of making calculations, and thus increased the amount of calculating which it is feasible to do. The threshold of engineering complexity has risen, from airplanes to power system networks. Computers have also contributed effectively to control applications, from telephone systems to oil refineries. Analogue and digital techniques have supplemented each other, and probably will continue to do so.

In the development of computing machinery, we see a new aspect of the industrial revolution. Machines are able to take over boring as well as burdensome jobs, and thus will raise the intellectual level of men's jobs as well as increasing their material wealth and providing more time for activities not immediately concerned with earning a living. It is clear that the future holds tremendous promise for the computer field.

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Residential Heat Pump Experiments—I

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AS A RESULT of experience in the operation of experimental heat pump systems in Philadelphia, Pa., it has become evident that it is necessary to direct efforts toward improving substantially the annual load factor of electrical service supply to such systems, to overcome the competitive handicaps inherent in utilizing electricity for house heating. The author believes that this objective may be accomplished through the development of economically feasible media for storing heat in sufficient quantities to permit a reduction in the maximum kilowatt demand for electricity of a heat pump system.

Figure 1 shows the relationships between the capacity of heating units and heat storage requirements. For climatic conditions similar to Philadelphia, the size of a heat storage system need not exceed a value which would be sufficient to meet the design heat requirements of a house with a heat pump of a size needed to satisfy the design requirements for summer cooling. This is about two-thirds the capacity which would be required under conventional conditions for heating.

Table I illustrates the significant features of calculated load characteristics of electrical service supply for several types of average heat pump systems. Under either of the methods of providing heat to storage, these types of heat pump systems produce annual load factors of electrical service supply substantially higher than is possible with either the Conventional type or even with the Ideal type, reaching levels which either approach or exceed those produced by the uncontrolled load of the residential class of customers as now constituted; and with a properly designed demand-energy rate, the total cost of electric energy for a heat pump system with the resistance method of storage does not need to be much higher than with the heat pump method of storage.

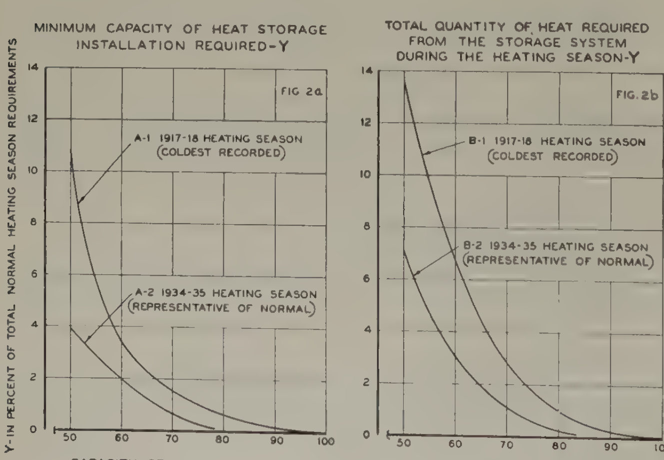

Figure 1. Relation of capacity of heating unit to minimum capacity of heat storage installation required and to total quantity of heat required from the storage system during the heating season

Table I

	Conventional Type	Ideal Type	Heat Storage Type With Heat to Storage Supply By: Method 1	Method 2
1. Btu per hour heat requirement (0–70 degrees Fahrenheit)	55,000	55,000	55,000	55,000
2. Maximum Btu per hour heat output of heat pump at 0 degrees Fahrenheit	85,000	55,000	35,750	35,750
3. Electrical load characteristics of heat pump system:				
(a) Maximum 30-minute demands, kw				
Noncoincident for year's cold spell	8.2	5.4	3.5	3.5
Diversified on day of 0 degrees Fahrenheit mean temperature	6.8	5.4	3.5	3.5
Diversified on average day of normal coldest week	5.7	4.0	3.5	3.5
(b) Annual energy for normal year, kwhr for heating requirements:				
By heat pump directly	9,550	9,550	8,850	8,600
By storage system			750	2,900
Total for heating	9,550	9,550	9,600	11,500
For cooling	1,000	1,000	1,000	1,000
Total for heating and cooling	10,550	10,550	10,600	12,500
(c) Coincidence factors, per cent:				
Based on diversified maximum demand, 0 degrees F day	83	100	100	100
Based on diversified maximum demand, average coldest day	70	74	100	100
(d) Annual load factors, per cent:				
Based on noncoincident maximum demand	14.7	22.4	34.6	40.8
Based on diversified maximum demand, 0 degrees F day	17.7	22.4	34.6	40.8
Based on diversified maximum demand, average coldest day	21.0	30.2	34.6	40.8

Conventional Type—Heat pump unit with generous margin in heat pump capacity and night setback in thermostat.

Ideal Type—Heat pump capacity equals heat requirements and fixed thermostat setting day and night.

Heat Storage Type—Heat pump unit with heating capacity 65 per cent of heat requirements and heat storage system containing material which stores heat in space substantially less than required with water as storage medium. Heat storage capacity sufficient to meet, together with heat pump, total heating requirements of coldest heating season on record. Calculated allowance for radiation heat losses of storage system assumed available to premises.

Method 1—Heat to storage supplied by heat pump when needed and at times when it is not called to furnish heating requirements.

Method 2—Heat to storage supplied by electric resistance elements when needed and only during periods when heat pump is not called to furnish heating requirements. (Patent applied for.)

As a result of the desirable levels of annual load factors feasible with heat storage type of heat pump systems, and under performance factors for this device, which are now possible of realization, it should be economically practical to supply electrical service to such systems at a price that would enable electricity to compete in cost of operation for house heating with other fuels such as coal, oil, or gas customarily used. This is generally conceded impractical of accomplishment with the use of electricity for house heating on a direct energy conversion basis. To reflect the benefits of high load factor operation, electrical service to heat pump systems should be supplied under a demand-energy form of rate.

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Residential Heat Pump Experiments—II

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EARTH SEEMS to be superior to air or water as a source for heat pumps. Its ambient temperature is igher and less variable than outdoor air, and its use loes not involve problems of accessibility or recirculation uch as would accompany the use of surface or underground water. However, little factual information has een available on the heat transfer characteristics of the arth, particularly as a heat source. Also, some investigators were apprehensive that prolonged heat withdrawal r absorption would have adverse effects upon the longerm temperature levels in the earth.

The purpose of the ground coil is to supply its associated eat pump with all of the heat which, when supplemented y the energy required for pump operation, will satisfy he requirements of the space to be heated. Experience as confirmed the assumption that the required ground oil output is very nearly two-thirds of the total space eating requirement.

The total heat required is extracted by what amounts o the equivalent of simple conduction at a relatively table average rate and average coil temperature, while he transient variations above and below the average rate re offset by the heat reservoir effects in the immediate icinity of the pipe. This is especially characteristic of perations with coil temperatures near 32 degrees Fahrenheit, because alternate freezing and thawing greatly mplify the heat storage effects.

An approximate analysis of the heat extraction rates nay be made using the Kennelly formula for steady state or which the rate per foot of coil is given by the expression

$$Q/L = E(Ta - T_c)/G \text{ average Btu per hour per foot} \qquad (1)$$

n which E represents an empirical earth conductivity and G accounts for the geometry of the ground coil (in this ase $G=1.2$). The heat-source values of the E thus btained varied from 1.6 for a 3-month period to 2.5 for he maximum day.

During certain periods of the test, the ground coil was perated below freezing temperature. Two major changes ccompany freezing. The principal effect is the release f heat from the immediate environment of the heat ollecting pipe. A secondary effect is that the earth has bout 50 per cent greater thermal conductivity after it is rozen. Both effects operate jointly to increase the heat xtraction capacity of the ground coil.

The average rate of heat extraction per degree Fahrenheit prior to freezing was about 1.1 (Btu)/(hour) (degrees ahrenheit) (foot) which corresponds to a value of $E=1.3$ or use in equation 1. When the coil temperature was epressed below 32 degrees Fahrenheit, the average rates f heat extraction per degree Fahrenheit increased, and ecame fairly constant. The average rates so observed aried from 1.3 to 1.8 corresponding to values of E of 1.55 and 2.2 respectively. The highest rate observed on a daily basis was 2.1 corresponding to a value of 2.5 for E.

The increased rate of heat extraction observed cannot be attributed to latent heat of freezing alone, and moisture migration is thought to be the only supplementary mode of heat transfer which might account for this.

Whenever the air spaces in the earth environment are only partly saturated with moisture, the introduction of a temperature differential causes a redistribution by migration of the moisture toward the region of lowest temperature. Stability is reached when the unbalanced forces of surface tension, vapor pressure, and gravity reach equilibrium. If there is sufficiently high water saturation at the cold surface, the conditions of stability may include some continual loss of moisture by gravitational drainage from the water saturated region. Such drainage would require the continuous supply of moisture from the warm regions toward the cold surface.

To provide the otherwise accounted for additional heat transfer observed in one instance would require the continuous movement of 3/4 pint of water or 40 cubic feet of water vapor per hour and foot of pipe. This seems almost reasonable, but rather larger than expected.

The possibility of moisture migration, therefore, must be kept in mind as an explanation of the comparatively high heat extraction rates observed. It must be realized, also, that if the frozen section is extended appreciably beyond that observed either by longer periods of frozen operation or by decreasing the coil temperature below 27 degrees Fahrenheit, the conditions governing this effect may be altered and the observed rates of heat withdrawal may not be maintained. This suggests that values of the empirical constant E which were representative of the maximum rates observed, may overstate the ground coil output to be expected for prolonged operation at a uniformly high extraction rate or at coil temperatures below 27 degrees Fahrenheit.

Operation under the cooling cycle indicated a representative value of E of 0.95. The difference between this value and the value of 1.3 observed prior to freezing is attributed to the effects of moisture migration which in the cooling cycle is in a direction away from the coil.

A survey of the earth temperatures in the vicinity of the ground coil prior to the start of the second heating season indicated that heat withdrawn during the first heating cycle had been restored completely. This should allay any apprehensions concerning the ability of the earth to recover completely during successive heating seasons.

Digest of paper 52-341, "Residential Heat Pump Experiments in Philadelphia—Earth as a Heat Source," recommended by the AIEE Committee on Domestic and Commercial Applications and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Residential Heat Pump Experiments—III

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IN ORDER TO INVESTIGATE the practicability of using heat pumps for year-round residential heating and cooling in the Philadelphia, Pa., area, two experimental installations were operated for 2 years, using the earth as a heat source and heat sink.

The self-contained heat pump unit shown in Figure 1 transferred heat from and to the earth by means of an ethylene glycol solution circulating in pipes buried in the earth. Heat was transferred to and from the homes by circulating hot or cool air through the existing heating ducts. Auxiliary electric resistance heaters were provided to meet requirements beyond the capacity of the units.

The annual load factors experienced (Table I, 7*a*) were exceedingly low. In restating the results, had the heat pump capacity equaled the design heating requirements of the homes, the system would still not have reached satisfactory annual load factor levels from the standpoint of an economical power supply (Table I, 8*e*). The heat pump units alone reached very desirable annual load factors (Table I, 7*c*) largely because the capacity of the units was well below the heating requirements of the homes.

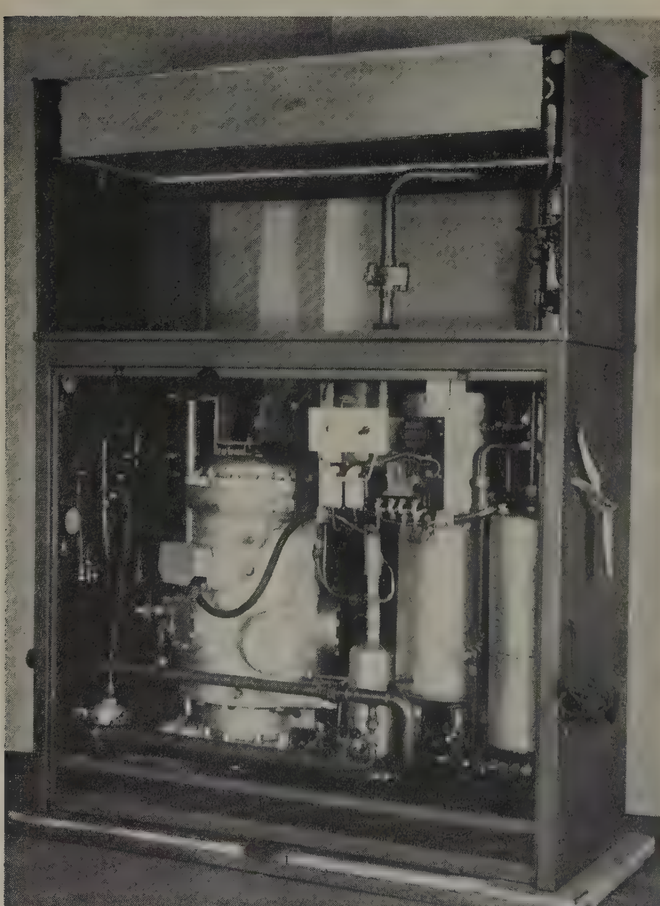

Figure 1. Heat pump unit

Table I. Summary of Significant Data

	Whitemarsh 1948–49	Whitemarsh 1949–50	Lansdowne 1948–49	Lansdowne 1949–50
1. Calculated heating requirements (of 0–70 degrees Fahrenheit) Btu per hour	90,000	90,000	75,000	75,000
2. Heat pump compressor capacity, horsepower	5	7.5	5	5
3. Maximum heat pump output (December-January-February) Btu per hour	45,700	55,100	38,300	38,800
4. Performance factor for the heating season	2.49	2.32	2.38	2.71
5. Annual energy use, kilowatt-hours				
(*a*) Heating—Heat pump, including glycol pump	15,248	20,835	9,855	10,801
Resistance heaters	2,384	772	538	732
Total for heating	17,632	21,607	10,393	11,533
(*b*) Cooling	3,491	2,796	1,204	705
(*c*) Total—heating and cooling	21,123	24,403	11,597	12,238
6. Maximum 30-minute demands, kilowatts:				
(*a*) Annual of system (including resistance heaters)	21.4	21.9	20.8	19.8
(*b*) Heat pump, including glycol pump (December-January-February)	5.4	6.7	5.1	4.3
7. Annual load factors, per cent:				
(*a*) Heating only (based on 6*a*)	9.4	11.3	5.7	6.7
(*b*) Total heating and cooling (based on 6*a*)	11.3	12.7	6.4	7.1
(*c*) Heating only (based on 6*b*)	39.6	40.3	24.8	30.5
8. Restated electric load characteristics:*				
(*a*) Heating annual energy use, kilowatts	16,205	21,168	10,081	11,071
(*b*) Cooling annual energy use, kilowatts	3,491	2,796	1,204	705
(*c*) Total, heating and cooling	19,696	23,964	11,285	11,776
(*d*) Annual maximum 30-minute demand of system, kilowatts	10.6	11.4	9.2	8.1
(*e*) Annual load factor, heating only—per cent	17.5	21.2	12.5	15.6
(*f*) Annual load factor, heating and cooling	21.2	24.0	14.0	16.6

* Restatement reflects estimated conditions (based on the experienced performance factors) had the maximum winter output of the heat pump been equal to the calculated heating requirements.

This indicates the necessity of using heat pumps with capacities below the design heating requirements of the premises, provided the supplementary heat required during severe cold periods is introduced in such a way as not to exceed the maximum demand of the heat pump.

The two installations performed effectively their task of providing year-round air comfort in the home, the earth providing a reliable heat source and heat sink at all times.

To obtain maximum desirability as a utility load builder and to compete most advantageously with other fuels, the heating capacity of heat pump installations should be limited to the required capacity for cooling. Supplementary heating for the peaks must be met so as not to create demands on the electric supply system which would exceed the maximum demand of the heat pump. This improvement might be achieved through the introduction of heat storage with the heat pumps.

Digest of paper 52-342, "Residential Heat Pump Experiments in Philadelphia—Installation and Operating Experience," recommended by the AIEE Committee on Domestic and Commercial Applications and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Television in Industry

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Industrial television is held to have a greater future in all probability than commercial television. Several of its important applications are discussed showing how it fulfils a definite need at nominal cost from both monetary and safety standpoints.

TELEVISION unquestionably has a place in industry and even at this comparatively early stage of its development its increasing acceptance, as well as uses now visualized for it in the future, indicate that its potential for industry is probably greater than that to be realized commercially.

Actually, it was first considered as an industrial device, rather than a medium of entertainment, and so it is understandable that television's pioneers today are somewhat bewildered that its use as a technological instrument has been overshadowed by its growth commercially.

Television's commercial development, however, came earlier since industrial television (ITV) did not come into being until after World War II. The special closed circuit systems which saw action in providing a means of guiding bombs or maneuvering drone planes were direct forerunners of the equipment used industrially today.

Commercial television had already become familiar to the public by the time ITV had been initially developed and thus gave rise to a tendency on the part of prospective users to judge the latter on the merits and shortcomings of the former. This was an unintentional injustice to both. Thus, ITV's pioneers were beset from the start with the task of making it known that

1. ITV enjoys a great comparative freedom of intricacy and complexity.

2. ITV's purpose is vastly different than that indicated for television commercially.

3. The conditions encountered industrially, as well as the purpose to be served, demanded a radical change in design and construction from that characteristic of commercial equipment.

In short, it was necessary from the start to emphasize that ITV was a "work horse," not a "show horse."

Television performs the following basic functions in industry: 1. It reduces accidents. 2. It reduces operating costs. 3. It reduces capital investment. 4. Under certain conditions, it provides greater intelligence than can be gained by direct observation.

Depending on the application, one or more of these functions is served.

In order for television to serve any industry, and especially the power industry, in these ways it must be designed with these thoughts uppermost in mind: 1. Simplicity of operation. 2. Dependability. 3. Freedom from excessive service requirements. 4. Long life. 5. Satisfactory performance. 6. Reasonable cost. 7. Portability.

The proper evaluation of these seven factors requires that each factor be compromised in favor of all others if a practical ITV system is to be obtained.

A television system is an electro-optical device. In optical devices the combination of high resolution, high sensitivity, broad response, and faithful contrast reproduction are incompatible unless achieved along with extreme complexity, high cost, unreliable operation under average conditions, constant maintenance, and bulkiness.

In electric devices service problems are proportional to the number of tubes and components, the complexity of circuit functions, and the severity of conditions under which the device must operate. Therefore, the main task in design of ITV was to find the optimum point of balance between complexity and picture quality.

It was found that, by employing a long-life "cold-cathode" tube, without a filament or electron gun, with a consequent slight reduction of picture definition, television equipment could be evolved which would operate, independent of supervision, on a continuous basis, 24 hours a day; would remain in adjustment once set; would be simple enough for personnel of using organizations to maintain in most instances; would represent an operational and maintenance cost comparable to that of the average control panel instrument; would maintain its adjustment regardless of temperature variations between

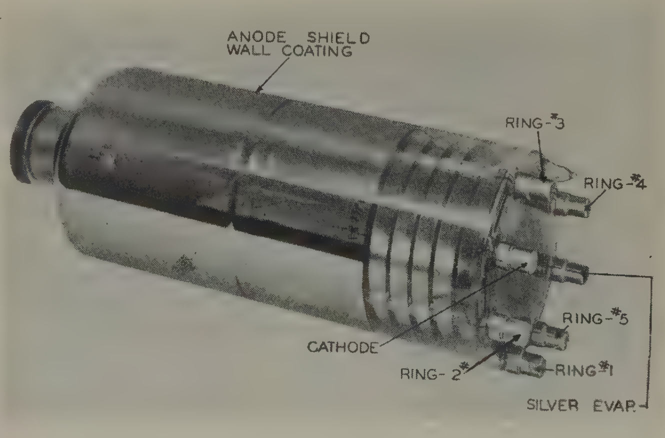

Figure 1. The image dissector, the most widely used television camera tube for industrial applications

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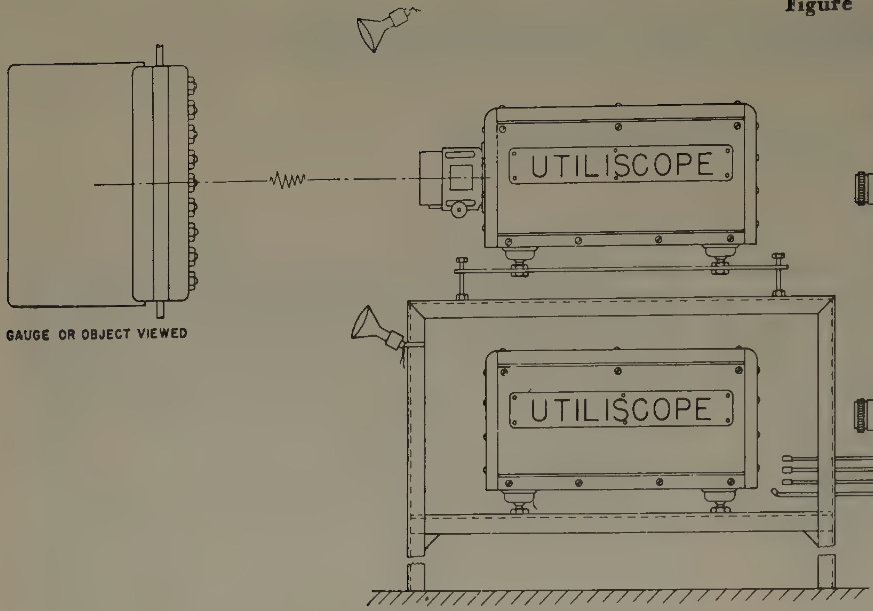
Figure 2. Typical industrial television installation



0 and 150 degrees Fahrenheit and in the face of vibrations far in excess of those encountered industrially under average conditions; would produce a medium definition picture instantaneously and continuously at any distance, the separation between camera and viewer being limited only to necessity of booster amplification when it surpassed 1,500 feet. Moreover, this equipment could be guaranteed under these conditions for 1 year.

In contrast to this, its commercial counterpart, ignoring the complexity attendant on the greater scope of operations involved, could not operate on a continuous basis as industry visualizes the phrase, required close temperature operating limits if readjustment was to be avoided, was unable to withstand vibration and other adverse conditions beyond those normally encountered in the laboratory, basically required from five to ten times the number of tubes to produce a picture, required camera tube replacement every 200 to 300 hours, and needed the maintenance efforts of experts.

This comparison should not be construed as talking down commercial television equipment for it represents optimum design based on a particular need. However, it does serve to indicate how vastly different the two types of equipment are and how erroneous are any preconceived notions about ITV based on data about equipment used for entertainment purposes.

To face the issue squarely, it should be explained that ITV's simplicity was achieved in the case of the Utiliscope at the expense of sensitivity which is so all important in broadcasting. There can be no argument, however, that there was much to be gained at the expense of adding from 50 to 150 foot-candles of scene illumination to that already provided. A record of over 200 installations completed or soon to be completed, after starting from the beginning with a totally new device in 1946, amply endorses this argument.

Figure 1 illustrates the image dissector, the cold-cathode type of camera tube referred to previously, and the one most widely used in industrial applications today. Its method of functioning will be explained later.

The average type of installation involving ITV is depicted basically in Figure 2. A camera employing the image dissector is placed in a fixed position, viewing an object or process whose position and/or movement can be viewed without need of lens readjustment. Close by the camera, but as far as 100 feet away if necessary, is the camera's power supply. At the control position is the monitor, or viewer as it is sometimes called, receiving picture information by means of coaxial cable.

This illustration is typical of an installation in the power industry wherein television is employed to transmit water level indication from a gauge at the drum level of a large boiler to the operator's position, the distance of transmission involved being sometimes as much as 250 feet, usually in excess of 100 feet. Thus the operator has remote vision since he is visually at the gauge position although actually a considerable distance away. The two words, "remote vision," admirably sum up the purpose of ITV.

The problem of remote vision has plagued industry for

Figure 3. Television observing water level gauge

Figure 4. Picture of the gauge shown in Figure 3 on television monitor located on operator's control panel

a long time. Where line of sight was obstructed mirrors were used, but since the size of an object decreased as distance increased, this method had its limitations. Alternatively, operations could be monitored indirectly by metering critical measurements—but this method was indirect and therefore provided only a substitute for remote vision. It remained for television to bring the subject close to the observer though at a considerable distance.

In the matter of gauge observation, moreover, ITV has a particularly important advantage over indicating instruments. To explain it adequately, it is necessary to go back to the years shortly following the last war. The upsurge in demand for electricity had resulted in the erection of much larger boilers than had been in use previously. As a result the distance between operator and the drum level gauges, which supplied him with critical information, increased accordingly. In some cases the gauge images, transmitted by mirrors, were so small, because of the distance of transmission, that water level indication was no longer clearly observable. To counter this problem remote position indicators were employed to provide water level information clearly, which they did. The possibility that such devices could lose calibration to the extent of indicating water in the boiler when, in reality, there was none, was considered fairly remote, especially if two of these indicators were used simultaneously, to check each other.

However, two very costly boiler accidents occurred in the eastern part of the United States shortly after the last war. Investigation showed that, in each instance, both indicators had shown water within the drum after it had been depleted.

At this point television stepped in to provide not only a picture but to place in the hands of the operator a fail-safe instrument. Unlike the indicators, it could never provide a wrong answer; it could never show water level when there was none, an advantage of paramount importance. This basic consideration was for the most part responsible for television's entry into the power industry and its widespread use in this application today.

The end purpose of ITV in this case, of course, is to reduce accidents, but there are others. In many instances, it was found necessary to employ a "water tender," a man directly to observe water level at the gauge position frequently and report to the control operator. By using television to provide continuous observation by the operator, the services of a direct observer could be dispensed with. Thus, ITV reduced operational costs by the reduction of labor costs—another basic function.

Furthermore, it was possible by deciding on the use of television while a station was in the design stages, to reduce capital expenditure. Costly engineering and construction of the duct work and line-of-sight openings needed for transmission of the gauge image by mirrors could be eliminated. In one case a spokesman of a large eastern utility company stated that, on the basis of previous experience and considering all the attendant expenses involved, a saving of over $10,000 per boiler could be realized by the elimination of this work.

Also of importance, in this application particularly, is the fact that, while the operator must stand in a precise spot to observe mirror transmission of a gauge image, he is not so restricted when television is employed. A reliable indication of water level can be seen on the monitor screen from anywhere within an arc of 125 degrees and, in the average case, up to 20 feet or more.

Figure 3 illustrates a television installation at the Tidd Station, Ohio Power Company, Brilliant, Ohio. Figure 4 shows the picture at the operating position. This is one of the early Utiliscope installations and, of course, is still in satisfactory operation. Since the time of its installation, equipment redesign has resulted in improved picture quality, greater serviceability, and improved appearance, although operation is fundamentally the same. The latest type of equipment is depicted in Figure 5. Of interest is

Figure 5. Latest type of industrial television equipment with remotely controlled lens turret

Figure 6. Weatherproof housing containing television camera viewing smoke-stacks

Figure 7. Smokestack picture on television monitor located above firing aisle within power plant shown in Figure 6

the dual lens arrangement shown; an accessory that, while not needed for gauge observation, has proved valuable in other types of applications in industry and is completely controlled from the monitor position.

ITV's progress in the power industry has developed additional applications and shows promise of others. The power industry is finding the Utiliscope valuable in providing a means of remotely observing boiler furnace interiors, one of the most rapidly expanding applications at the present time. Recent engineering, incidentally, has made it possible to obtain desired results in connection with natural gas firing. Due to flame color and lack of density, natural gas flame had defied earlier attempts at providing a satisfactory picture with the standard type of image dissector which had already proved itself in connection with other types of firing. By employing in the dissector a photosensitive surface similar to that recently developed for the military, the flame pattern of natural gas is clearly discernible, thus making it possible to observe with the Utiliscope all types of firing in prominent use today.

Other power plant uses include smokestack observation. The initial Utiliscope installation for that purpose was made some time ago at the State Line generating station of the Chicago District Electric Generating Corporation, Hammond, Ind. Its success has been instrumental in developing interest elsewhere, and as a result, a nearby utility company will soon have a similar installation with the likelihood of others to follow. Figure 6 shows the camera location and the simple type of weatherproof housing being used successfully at the State Line station. Figure 7 indicates how the picture appears on one of two monitors located above the firing aisles within the plant.

It is but a matter of time, judging from present indications, before watchmen and guards will patrol remotely located plant gates through the eyes of television. The equipment employed will be quite similar to that used for stack observation except for the addition of lights to allow for nighttime visibility. The entry of unauthorized persons, identification of employees, and regulation of vehicular traffic are specific situations which can be handled remotely and at less operational cost with television.

Another contemplated use involves the remote observation of critical meters or indicating devices at unmanned stations or substations. It has already been proved by demonstration that Utiliscope equipment can be used successfully in connection with ultrahigh-frequency point-to-point transmitting equipment. It has also been demonstrated that it can be adapted for use with a carrier system, thus making it possible to span greater distances between camera and monitor than might otherwise be feasible because of property boundaries or existing underground conduit facilities. While such applications involve additional equipment, in the power field particularly this is often already available so that augmenting the required service is a comparatively simple matter. Therefore, it is believed that this general type of application will, like the others, be pioneered by this industry.

It is indeed fortunate that the Utiliscope's first use in industry subjected it to the rigorous requirements of power plant use. The experience gained from such early installations was of considerable value in engineering other applications which were to increase its usefulness to industry

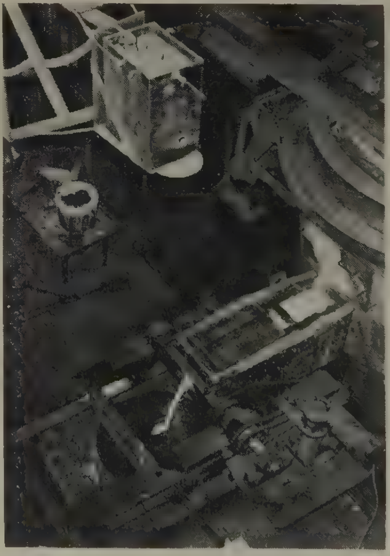


Figure 8. Television camera in air-cooled housing viewing the pouring of continuous billet

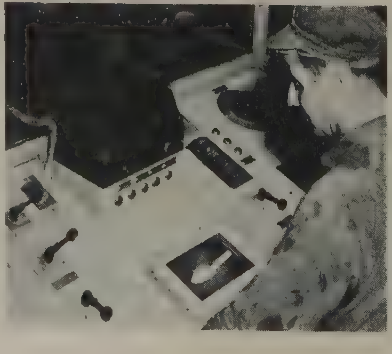


Figure 9. Control operator viewing mold-pouring picture on monitor built into control console

Figure 10. Slab-spotting Utiliscope camera which views the entrance of a reheat furnace

One of the first applications to be made outside the power plant involved the remote observation of high explosives which were undergoing machining operations. The hazards to human life involved in such a process dictated the need for remote rather than direct control.

Once this application became established at a government arsenal in the Midwest, similar problems at other government installations were solved in a like manner. Although the process to be viewed varied in most instances, the same purpose was served. Later installations included equipment for remotely observing bomb disassembly at Picatinny Arsenal; similar equipment viewed hazardous devices on test at Aberdeen Proving Grounds, Md., and United States Naval Ordnance Test Station, Inyokern, Calif. A Utiliscope was recently installed at Watertown Arsenal near Boston, Mass., to safeguard observers watching numerous types of destructive tests where the possibility of explosion is ever present. As there was need for greater flexibility of operation in these instances, equipment illustrated in Figure 5 was engineered from the type used for gauge observation, as shown in Figure 3.

The steel industry soon followed the power industry in visualizing the advantages of control with the help of television. At Babcock and Wilcox Tube Company, Beaver Falls, Pa., control of a continuous billet-pouring process was centralized in the hands of one man who formerly had to rely on hand signals from an assistant at the mold entrance who was subjected to unfavorable working conditions. Figure 8 shows the Utiliscope camera location and Figure 9 the observing position with the monitor built into the control console.

At Geneva Steel Company in Utah, television now enables a control operator to be visually in four places at one time. Previously, he relied on the verbal instructions or hand signals of men stationed at the entrances of several reheat furnaces so that steel slabs could be properly positioned in front of the respective entrances, thus eliminating the possibility of misaligned slabs damaging the furnaces when forcibly pushed into the entrances by mechanical means which the central operator controlled. See Figures 10 and 11.

A job of furnace viewing quite different from that usually employed in the power plant is being accomplished at the Timken Roller Bearing Company, Canton, Ohio. As illustrated in Figures 12 and 13 a control operator views tubes at a cooling furnace entrance so that pile-ups, which might impair the control of uniform heat loss, can be eliminated without the necessity of stationing an extra man at the furnace entrance. The camera and monitor are about 100 feet apart making image transmission by the use of mirrors unsatisfactory.

Just as new applications have arisen in the power field, new means of usefulness are being constantly discovered for the Utiliscope in other industries. A recent government installation involves the remote observation of models within the test chamber of a wind tunnel.

The Utiliscope is now being used to help centralize control of large-scale scrap paper weighing operations. Information in regard to weight and classification from three separate platforms will be handled by one man instead of three which would normally be required. The use of television also will discourage any tendency for an individual to put his foot on the scale, unintentionally or otherwise.

The constantly increasing number of applications, plus the fact that differences in design of facilities in conjunction with which television equipment is to be used,

Figure 11. Control operator's position, showing two of four monitors. Pictures on screens show furnace entrances

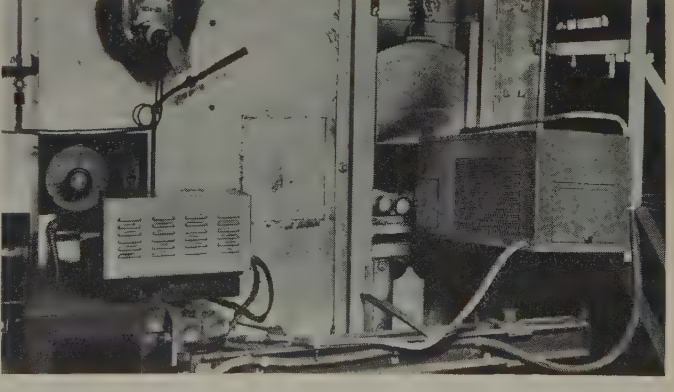


Figure 12. Television camera in air-cooled enclosure viewing tubes in cooling oven

placed particular emphasis on the importance of application engineering. Thus far there has not been much opportunity for standardization. Very seldom is there the need for nothing other than basic television equipment. Special enclosures must be designed to counter extremely severe conditions of temperature and dust, protective windows of proper design must be furnished where furnaces are to be viewed. Traversing and elevating mechanisms, special supports, and special mounting facilities must be designed to cope with problem of restricted installation space, special circuitry has been devised to meet the requirements of certain applications. Special remotely controlled lens and lens turrets have been designed to provide flexibility of operation. In short, basic television equipment comprises only a portion, albeit an important one, of an ITV installation.

On the basis of these considerations and because television is probably the most advanced type of communication, as far as relaying exact information is concerned, it is not hard to understand, as we mentioned earlier, that it might be considered complicated. Basically the principle of television is not complicated however.

The conversion of light into electricity at the camera is accomplished by photosensitive material within the camera tube. In the case of the cold-cathode image dissector this is called caesium oxide silver. This material has the ability to give off electrons when subjected to light, the amount of electrons being directly proportional to light intensity. A functional cross section of this tube is illustrated in Figure 14. First it will be noticed that no special source of electrons such as a hot filament is required, as it is in other types of camera tubes. The internal energy is supplied by the caesium surface which is constantly replenished. Thus, tube life is many times greater than that of hot-cathode tubes, as it is limited only by abuse or a gradual leakage of air through the glass envelope which, based on laboratory tests of an average tube, would reduce the vacuum within the tube sufficiently noticeably to affect picture quality after 15 years of continuous operation. While this remarkable life expectancy is based on laboratory tests only, the fact that image dissectors installed 5 years ago are still in satisfactory operation today,

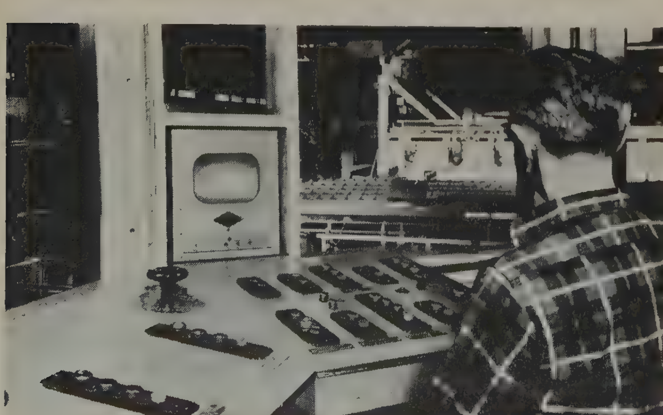


Figure 13. Operator viewing tubes in oven. He avoids pile-ups by controlling the tubes rate of movement as necessary. The camera is located at the far side of the oven in the background

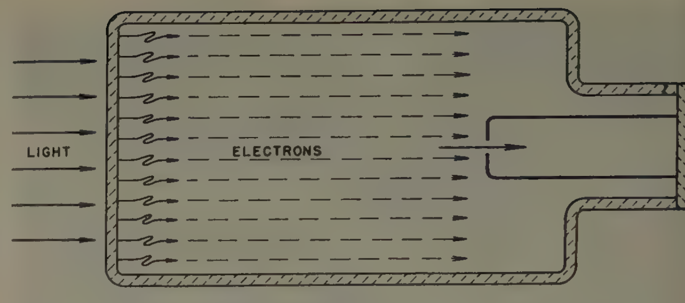


Figure 14. Functional cross section of image-dissector-type television camera tube

suggests that these tests are indicative. As can be seen from the illustration, travel of the electrons from the front surface of the tube is directed back to a small aperture. Under static conditions only the electrons coming from a very restricted area will pass through and can then be amplified to sufficient proportions for transmission within cable. However, as in the case of the viewer, or monitor, these electrons are deflected so that, in the course of 1/60th of a second, electrons from each portion of the image present on the face of the camera tube pass through the aperture. If a particular area is brighter than that surrounding it, more electrons will be liberated from the caesium surface and will pass through the aperture at the proper instant. The greater number of electrons, after being amplified and sent over the cable, give greater force to the electron beam within the picture tube resulting in a brighter spot.

Thus, it can be seen that the real picture information in television is obtained through variation of the dot's intensity as it travels back and forth. This provides to the eye graduations from black through all shades of gray to white. We have seen that these graduations originally are determined by the amount of electric energy, the number of electrons, liberated from various points on the surface of the camera tube. That the tremendously varied graduations of light on a subject such as a human face can be faithfully relayed, recorded, and produced so rapidly by the method explained can perhaps be imagined. If so, it is marvelous to contemplate and shows how much science has put nature to work. It is the more marvelous to contemplate as one's understanding of it increases.

The fact still remains, however, that ITV has not progressed simply because it is new and perhaps represents a radical departure from conventional instrumentation. It has performed one or more of the basic functions previously mentioned, fulfilling a definite need at nominal cost. As developments occur in the art, those that can be incorporated in industrial equipment will result in improved performance in present applications and greatly expanding the field of new applications whose requirements, particularly in regard to picture quality, are more stringent.

Certainly, if it is true of any other modern development, it can be said that in this field the surface has hardly been scratched. Accepting this then, it is reasonable to expect that industry can benefit from television in direct relationship to its interest in determining how to apply it. This is a challenge, but since challenge promotes progress, its acceptance should inevitably lead to greater benefits.

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EXPERIENCE OF 42 sleet seasons has enabled the Pennsylvania Water and Power Company to develop methods of combating sleet accumulations which provide satisfactory performance of lines susceptible to sleet troubles. Design improvements also have been made, and a 1931 design has given perfect performance in an area where sleet storms are prevalent.

For sleet forecasting and detection the usual weather reports are used together with observations on this and neighboring systems, including observations by patrolmen and residents along the lines. Hydrogenerators or frequency changers supply heating current to the circuit through special sleet busses and disconnectors, with the other end of the circuit short-circuited and grounded.

The first 66-kv line, see Figure 1, was built from Holtwood, Pa., to Baltimore, Md., in 1910. Present sleet-melting practice is to apply 425 amperes for 40 minutes to the 300,000-circular-mil all-aluminum conductors. During high winds and low temperatures the current reaches about 450 amperes. The second line was constructed on the same right of way in 1914, using the same size conductor. Design improvements included an increase in vertical conductor spacing from 7 to 9 feet, and different length crossarms to provide horizontal conductor separation. The vertical spacing was further increased in the 1923 design for 66-kv lines from Holtwood to York, Coatesville, and Lancaster, Pa. Though improved, these lines are still susceptible to sleet troubles and must be heated. The later lines have 00 copper conductors, heated for 40 minutes at 450 amperes for usual conditions and at about 500 amperes for adverse conditions.

A 1923 design 10-mile line was built in 1925 with shorter spans almost all in strain. No sleet trouble has occurred although the conductors are not heated during sleet storms. This line is on the right of way with the 1910 and 1914 lines, and crosses known trouble spots where the older lines have failed since 1925.

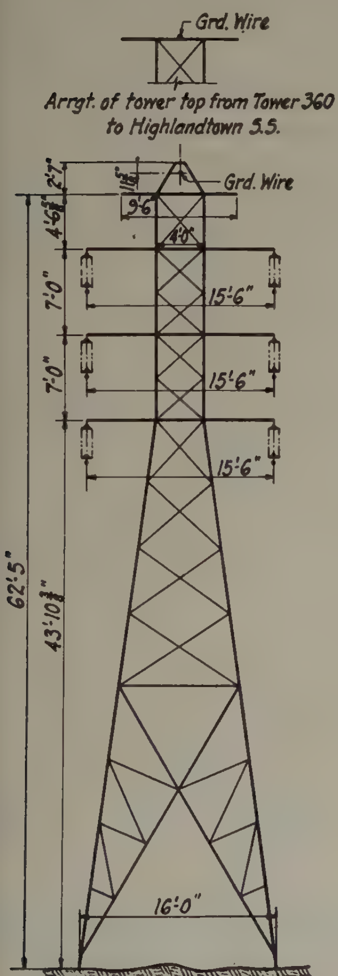

Figure 1. Double-circuit 66-kv 25-cycle 1910 line with 300,000-circular-mil all-aluminum conductor

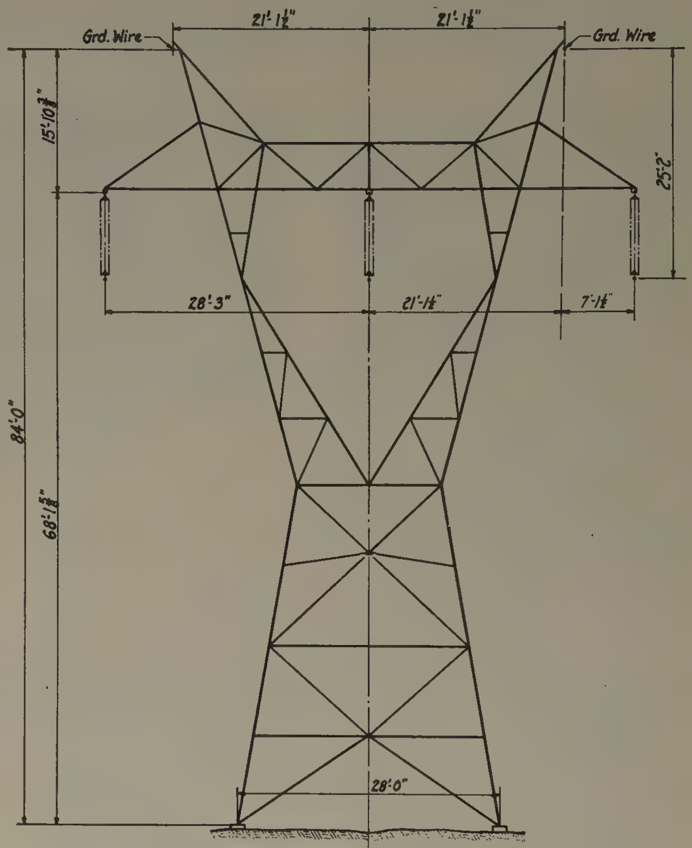

Figure 2. Single-circuit 220-kv 60-cycle 1931 and 1937 lines with 795,000-circular-mil steel-reinforced aluminum cable conductor

The first 220-kv line, see Figure 2, was built from Safe Harbor to Baltimore in 1931, and tapped and extended to Washington in 1933. The second line to Baltimore was installed in 1937 using the same design. No heating facilities are provided and no sleet trouble has occurred.

Experience shows that satisfactory performance of lines which are susceptible to sleet troubles can be obtained by heating the conductors without delay, although all outages cannot be eliminated. The 220-kv line experience shows that horizontal configuration steel tower lines can be built to be highly sleet resistant.

Digest of paper 52-187, "42 Years' Experience Combating Sleet Accumulation," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Comparative Studies of New Push-Pull Methods for Pole-Top Resuscitation

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All push-pull pole-top methods of resuscitation, evaluated on five apneic subjects, proved $1^1/_2$ times as effective for pulmonary ventilation as the standard pole-top method. The double-rock push-pull seems best for several reasons. A discussion by E. W. Oesterreich questions the advisability of adopting this new system unless it can be proved conclusively either that the present method is inadequate or the new method more effective and that it does not sacrifice any advantages now obtained.

EFFICIENT laboratory methods for accurately determining the effectiveness of artificial respiration have crystallized most issues regarding manual resuscitation.[1,2] Recently, numerous corroboratory studies have established the unequivocal superiority of push-pull techniques over push-only and pull-only maneuvers.[3–11] As a result, almost all national and federal agencies have endorsed the use of these methods.[12–14]

The natural outgrowth of this has been the suggestion by several groups in the electrical industry that the push-pull principle be applied to pole-top resuscitation. Adequate appraisal of the ventilatory efficiency of these proposed methods requires comparative studies on subjects who actually simulate victims requiring resuscitation. Previous tests in this laboratory have validated the use of totally apneic, curarized-anesthetized, normal adults for this purpose. This report details their use again in comparative studies of standard pole-top, push-pull pole-top, and prone manual resuscitation methods.

GENERAL METHODS

FIVE NORMAL HEALTHY ADULT MALE VOLUNTEERS were used as subjects. They ranged in age from 21 to 26 years; all of them were between 70 and 72 inches in height; and their weight range was from 150 to 180 pounds.

Following preanesthetic atropinization (1/100 grain), they were curarized-anesthetized to total apnea by the method this group previously reported.[15] Each of them was rendered unconscious and in a flaccid state of respiratory arrest by the intravenous injection of Pentothal sodium (R) (0.5 gram) and d-tubocurarine chloride (15 milligrams) as a single dose over approximately 1/2 minute. An endotracheal tube, well lubricated with a water-soluble anesthetic ointment, was inserted into the trachea to maintain a clear airway at all times. This was secured by adhesive tape and an inflatable cuff which was expanded to assure a gastight system. The tube was connected to a carefully balanced recording spirometer by means of which pulmonary ventilation was measured. The subject was then placed in position for the type of artificial respiration to be studied.

After each method of artificial respiration had been performed, or at any indication of the return of spontaneous respiration, cyclopropane-oxygen mixtures were administered by intermittent positive pressure from a standard anesthetic machine. This maintained oxygenation and supplemented the curare-produced apnea.

After completion of the series of tests on each subject, nitrous oxide-oxygen was administered by intermittent positive pressure on the rebreathing bag until spontaneous respirations were adequate and muscular tone had returned. Tracheobronchial aspiration and extubation were then performed. All subjects were up and walking within $1^1/_2$ hours and were permitted to leave under supervision shortly thereafter.

Figure 1. Nonbreathing, unconscious subject astride rescuer's safety belt for application of pole-top resuscitation methods

METHODS OF ARTIFICIAL RESPIRATION STUDIED

THE VITAL CAPACITY and tidal volume were determined in each case during the pretest resting conscious state. Then complete series of methods were performed on each totally apneic subject. In order to provide a basis of comparison between these studies and previous tests, and

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These studies were accomplished with the technical assistance of J. E. Appel, Supervisor of Safety, and members of the Construction Department, Commonwealth Edison Company.

also between pole-top and standard methods, the Schafer method, and two of the recommended push-pull methods (arm-lift back-pressure, hip-lift back-pressure) were performed on each individual in addition to the standard pole-top and four suggested push-pull pole-top maneuvers.

All of the prone manual methods were applied by the same operator. The standard pole-top method and its modifications were performed on each subject by one of two trained, experienced utility linemen. The methods were rotated in the order of performance. The Schafer and standard push-pull methods were performed with the prone apneic subject on the unpadded floor. For the standard and push-pull pole-top methods he was secured by a lineman's belt and safety strap to a specially erected pole. See Figure 1.

SCHAFER PRONE PRESSURE METHOD

UNTIL RECENTLY, this well-known and easily performed method was preferred in this country. It is a push-only technique which results in active expiration and passive inspiration. The operator straddles one or both legs of the prone victim, who is placed with the elbows flexed and the face turned to the side, resting on the back of one hand. The operator places his hands, with the fingers together, over the floating ribs. He then rocks forward exerting moderate pressure for approximately 2 seconds. The pressure is then released to complete a 5-second cycle.

Previous studies in this laboratory[16] have shown that back-pressure over the mid-back (at the lower tips of the scapulae) with the fingers spread and the thumbs near the spine, results in $1\frac{1}{2}$ times as much pulmonary ventilation as standard prone pressure. Accordingly, both prone pressure and back-pressure were evaluated here.

ARM-LIFT BACK-PRESSURE METHOD

THIS BACK-PRESSURE ARM-LIFT push-pull method, modified from the Holger Nielsen,[17] also uses the prone position. However, for this technique the arms are flexed, the hands placed upon each other, the head turned to one side and placed on the backs of the hands. See Figure 2.

The operator kneels at the victim's head, facing him. He may kneel on either knee or on both if this is more comfortable. The operator places his hands under the arms of the victim just above the elbows. He then rocks backward, keeping his elbows straight and drawing the victim's arms upward and toward himself. This lift is continued until firm resistance is met. The arms are then replaced on the ground and the operator moves his hands to the patient's back. He places his hands over the mid-back with the fingers spread downward and outward, the thumbs touching at the spine and the heels of the palms at the level of an imaginary line between the two axillae. He then rocks forward, keeping his arms straight, and allows the weight of the upper part of his body to exert steady, gradual pressure almost vertically downward upon his hands until he meets firm resistance. Each phase occupies an equal amount of time, and 10 to 12 cycles are performed per minute.

The arm-lift results in active inspiration by: (1) tensing the pectoral musculature, which pulls on the ribs, resulting in a widening of the intercostal spaces; (2) relieving the weight of the body from the sternum, which allows increase in the transverse and antero-posterior diameters of the chest; and (3) slightly hyperextending the spine, thereby inducing further widening of intercostal spaces. Back-pressure produces active expiration.

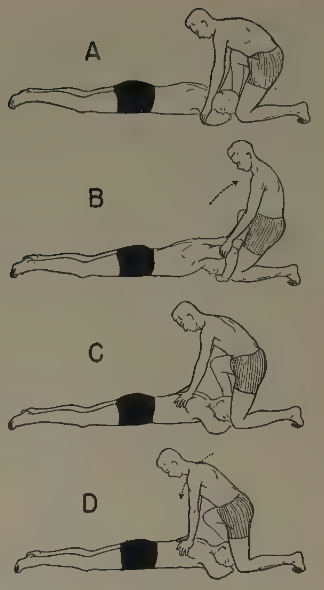

Figure 2. **Arm-lift back-pressure method of artificial respiration**

A—Place hands under arms
B—Lift arms
C—Place hands on back
D—Press back

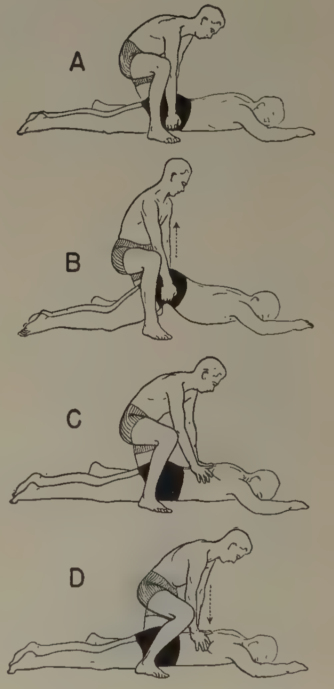

Figure 3. **Hip-lift back-pressure method of artificial respiration**

A—Place hands under hips
B—Lift hips
C—Place hands on back
D—Press back

HIP-LIFT BACK-PRESSURE METHOD

FOR THIS PUSH-PULL METHOD, the operator kneels on either the right or the left knee at the level of the patient's hips. The other foot straddles the victim and is placed on the ground near his opposite hip. Thus, the heel is directly opposite the kneeling knee. See Figure 3. The operator places his hands under the victim's hips and lifts them upward approximately four to six inches. This allows the abdomen to sag downward, the diaphragm

descends, and air is actively sucked into the lungs. The operator's arms are kept straight during the lift so that the work is done by the shoulders and back rather than by the arms. The hips are then replaced on the ground and the hands are moved to the mid-back, over the lower tips of the shoulder blades. The operator then rocks forward and allows the weight of the upper part of his body to exert gradual pressure almost vertically downward until he meets firm resistance. The fingers are kept spread and the thumbs almost touch at the spine. The elbows are also kept straight during the back-pressure phase. Ten to 12 complete cycles per minute are performed.

An adjunct, such as a belt, rope, towel, or the like, may be used under the hips to assist in lifting.

POLE-TOP METHOD

THIS METHOD FOR RESUSCITATING LINEMEN shocked on the poles has found wide and successful applications since its original description by Oesterreich.[18] Immediate application of manual artificial respiration on the pole eliminates the tragic delay involved in first lowering the victim to the ground.

The studies of Kouwenhoven, Hooker, and Langworthy[19] showed that the pole-top method gave greater ventilation than Schafer's prone pressure in volunteers with passively suspended respiration. More recently, Gordon and others, used totally apneic, curarized-anesthetized subjects to substantiate this finding.[16]

Figure 4. Double-rock method of push-pull pole-top resuscitation

A—Place hands for expiratory phase
B—Rock back during expiration
C—Raise hands for arm-lift phase during inspiration
D—Rock back during arm lift

In the performance of pole-top resuscitation, the rescuer immediately ascends to the victim. He secures his safety strap around the pole and places the victim astride it between himself and the pole. He encircles the waist of the victim with his arms, placing both hands on the abdomen, thumbs below the lower ribs and fingers touching. With his arms and hands, he compresses the victim's abdomen in an upward motion. At the finish of the stroke, the hands are cupped with the fingers depressing the abdomen under the rib margin. The pressure is quickly released and reapplied at a frequency of 12 to 15 times per minute.

PUSH-PULL POLE-TOP RESUSCITATION METHODS

IT WAS SUGGESTED by J. E. Appel, Supervisor of Safety, Commonwealth Edison Company, that application of the push-pull principle to pole-top resuscitation would significantly increase pulmonary ventilation by producing active inspiration as well as active expiration. This led to the development of several modifications by his staff. These push-pull pole-top maneuvers are referred to by their descriptive terms: (1). double-rock; (2). single-rock; and (3). forward-rock.

Concurrently, R. J. Young, Safety Engineer, Public Service Company of Indiana, suggested another manipulation for application of push-pull resuscitation on the pole. This is referred to as the arm-grasp.

Recently, Karpovich and Hale have evaluated and recommended a push-pull modification of pole-top resuscitation.[20] However, they used conscious volunteers and compressed the chest rather than the abdomen for the expiratory phase.

1. Double-Rock Method. See Figure 4. The rescuer places the victim astride his safety belt as for the standard pole-top method. After encircling the victim's waist with his arms and placing both hands on the abdomen, he compresses the victim's abdomen with an upward motion, as described in the foregoing. The operator enhances this active expiration by a backward rock of his shoulders and upper body. He then releases the pressure and rocks forward to the resting position.

The rescuer then moves his hands upward over the victim's chest with the forearms in the axillae. He now rocks backward a second time and simultaneously draws his arms upward and backward. This lifts and stretches the victim's arms, widening the intercostal spaces by tensing the pectoral musculature and thereby producing active inspiration. The complete cycle is then repeated 10 to 12 times per minute.

2. Single-Rock Method. This modification is performed exactly like the double-rock except that the operator rocks backward only during the arm-lift or inspiratory phase. During the abdominal compression, or expiratory phase, he maintains his stationary upright posture.

3. Forward-Rock Method. In this suggested method, the rescuer performs as for the double-rock, with one exception. In order to try to increase the expiratory phase, he rocks forward during the abdominal compression,

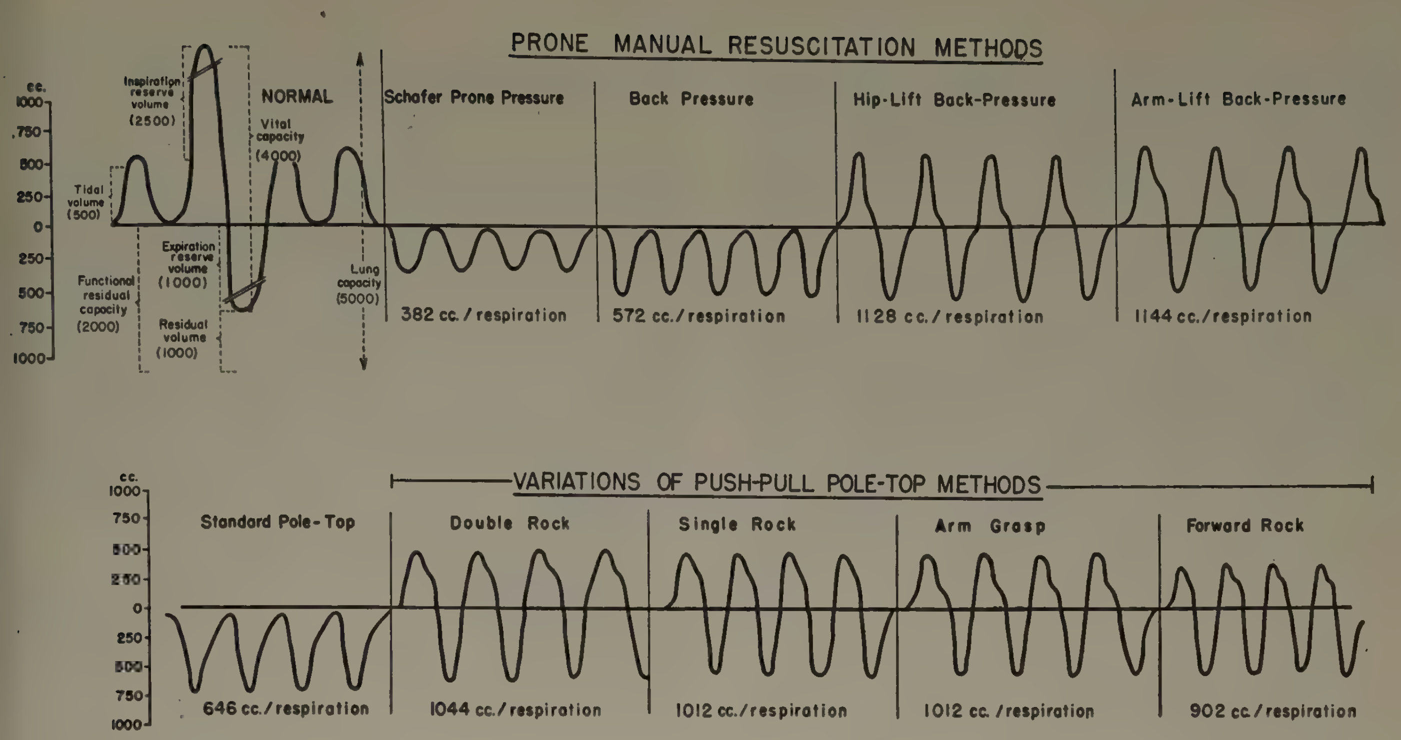

Figure 5. Respiratory graphs of various methods of artificial respiration

maintaining the backward-rock during the arm-lift, or inspiratory phase.

4. Arm-Grasp Method. This maneuver parallels the double-rock method. However, at the beginning the operator grasps the wrists of the victim in his hands. (He can grasp the victim's right and left wrist with his right and left hands, respectively, or he can cross his hands and grasp the victim's right and left wrists with his left and right hands, respectively.) The operator compresses the victim's abdomen while retaining his grasp of the wrists. He then lifts and draws back the victim's arms by raising the wrists and drawing them backward. During the complete cycle, and from cycle to cycle, he retains his hold on the wrists.

RESULTS

THE MEAN VALUES for the pulmonary ventilation achieved by all methods in all five subjects are listed in Table I. As in all previous studies by this group, the prone push-pull methods give two to three times as much pulmonary exchange as the push-only methods. The value for Schafer prone pressure is somewhat lower than usually attained by us in this type of subject. However, the earlier observation is substantiated that back-pressure, alone, gives $1^1/_2$ times as much ventilation as prone pressure, alone. There is no statistically significant difference between the ventilatory efficiency of the two prone push-pull methods employed here.

The standard pole-top method was superior to Schafer prone pressure and back-pressure, and approximately equal to results obtained in our earlier studies.[16] All of the push-pull pole-top methods were $1^1/_2$ times as efficient as the standard pole-top method, as regards pulmonary ventilation. Only the forward-rock method fell somewhat short of this achievement. The respiratory pattern obtained with each of the methods is shown in Figure 5. Utilization of only the expiratory reserve volume is evident with Schafer prone pressure, back-pressure, and standard pole-top methods.

Since three of the push-pull pole-top methods are equally superior to the standard pole-top technique, it becomes necessary to find some other criterion to use in the delineation of the best method. Each of the utility linemen was questioned when he finished each series of tests on the pole. Throughout the tests they remained in agreement that the arm-grasp method was most difficult to perform. They found it awkward to perform the abdominal compression while grasping the victim's wrists. In addition, it was found to be physically tiring and more than a little difficult to maintain a grasp on the victim's wrists during the arm-lift. These factors were reflected in the respira-

Table I. Pulmonary Ventilation with Manual Artificial Respiration

State	Method	Variation	Ventilation (Cubic Centimeters/Respiration)*
Conscious resting	Normal	Tidal volume	514
		Vital capacity	4,286
	Schafer	Prone pressure	382
		Back-pressure	572
		Standard	646
Unconscious apneic	Pole-top	Push-pull	
		Double-rock	1,044
		Single-rock	1,012
		Forward-rock	902
		Arm-grasp	1,012
	Prone push-pull	Arm-lift back-pressure	1,144
		Hip-lift back-pressure	1,128

* Mean values for five normal healthy adult male volunteers. All methods performed on all subjects at rate of 12 times per minute.

tory graphs taken during the performance of this method. Slipping of the wrists, and the necessity for taking frequent new and firmer holds, resulted in the production of numerous artifacts in the breathing curves. On the contrary, the double-rock and single-rock methods produced smooth, reproducible curves.

Of these two remaining methods, it was found to be easier to maintain a regular, smooth, easy rhythm with the double-rock method than with the single-rock. Although it was difficult to distinguish between the fatigue resulting from these two modifications, both operators felt as if they could perform the double-rock method longer, more steadily, and more smoothly.

REVIEW

The findings observed here justify the recommendation that push-pull pole-top resuscitation methods should supplant the standard pole-top method (push-only) wherever and whenever applicable. Of these the double-rock maneuver for inducing active inspiration and active expiration appears to be the best modification. Although it would seem that the forward-rock should produce greater expiratory volume due to additional abdominal compression, this did not prove to be the case. It may be attributed, perhaps, to awkwardness in performing a forward rock on the pole. The arm-grasp is unnecessarily difficult and results in interruptions of the respiratory pattern.

The addition of an active inspiratory phase should result in increased alveolar ventilation with the push-pull methods. In the presence of an efficiently functioning circulatory system, this augmented alveolar ventilation would improve the ventilation-perfusion ratio of the lungs and result in an elevated arterial oxygen saturation. This has been demonstrated with the prone push-pull methods.[9]

Furthermore, a failing circulatory system should be improved by the push-pull pole-top methods. During active expiration, compression of the abdomen should have a massaging or "milking" action upon the viscera, tending to direct the blood flow toward the heart, and to prevent vascular pooling in the splanchnic area. During active inspiration the arm-lift increases intrathoracic negativity by enlarging the antero-posterior diameter of the thorax. This will aid cardiac refill by drawing blood toward the heart.

Despite these observations regarding the circulatory benefits accruing from push-pull maneuvers, it is still felt that push-pull pole-top methods should be started at once but the victim requiring prolonged artificial respiration should be lowered to the ground as quickly as is practical, and one of the prone push-pull methods started. The vertical position on the pole favors vascular collapse, and the less deleterious prone position is to be preferred, as soon as it can be achieved.

Although a rate of 12 complete cycles per minute seems optimal, the increased length of the cycle, and the increased exertion may frequently necessitate a rate of 10 cycles per minute. With prolonged usage and growing fatigue, the operator may have to reduce his pace to 8 cycles per minute. In the absence of an assistant, if a rescuer becomes exhausted while performing the push-pull pole-top method for a long period of time, he can retreat to the easier standard pole-top maneuver briefly, until he feels that he can resume the push-pull technique.

As soon as the victim can be lowered to the ground, the arm-lift back-pressure or hip-lift back-pressure method should be continued until spontaneous respirations return or he is pronounced dead. When breathing returns, even if at a slow rate, the operator must synchronize his manipulations with the victim's efforts. Even after normal breathing has returned, the victim must be kept in a horizontal position until definitive medical care has arrived.

The arm-lift phase of the push-pull pole-top methods resulted in some chafing of the skin of the axillary and pectoral regions of these subjects. This will undoubtedly be noted in field applications of these new methods. However, this slight soreness is a price well worth paying for the additional benefits of the improved methods.

It has been noted that when the apneic subject is shifted from the horizontal to the vertical, the diaphragm descends somewhat, and the resting lung volume is increased. To this fact is due, at least in part, the greater expiratory volume achieved with the standard pole-top method than with the prone pressure or back-pressure methods. In these studies an attempt was made to determine the exact amount of increase in the resting lung volume level during the shift in position. However, the pressure of working with totally apneic human subjects and various technical difficulties prevented our making this determination.

SUMMARY

1. Push-pull pole-top methods have been evaluated on five normal, healthy, adult males in a totally apneic, unconscious state induced with curare-anesthesia mixtures.

2. All push-pull pole-top methods are found to be $1^1/_2$ times as efficient, as regards pulmonary ventilation, as the standard pole-top method.

3. Of the push-pull pole-top methods, the double-rock is generally the most applicable, as regards pulmonary ventilation, ease of performance, rhythm, and operator fatigue.

4. In addition, the push-pull pole-top methods should materially benefit a failing circulatory system. However, the dictum must be retained that pole-top resuscitation having been begun, the victim should be brought to the ground as soon as possible and manual artificial respiration continued, using one of the prone push-pull methods.

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Discussion of Article on Comparative Studies of New Push-Pull Methods for Pole-Top Resuscitation

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FELLOW AIEE

QUESTIONS HAVE BEEN RAISED, mostly by safety engineers of electric power supply companies, as to whether the basic principle of the recently accepted Holger-Nielsen push-pull prone method of artificial respiration is applicable as an advantageous revision of the pole-top method of artificial respiration. As a result of the authors' interest in the general problem of artificial respiration, there now is available for study and analysis, data based on well-planned and courageously executed laboratory tests. However, when a change from the time-proved practice is contemplated, serious consideration must be given to two factors of primary importance, namely, whether the present practice is inadequate, either from an application or efficiency viewpoint, or whether the present practice can be replaced by another which is more effective without greatly sacrificing any advantages of the one being replaced.

When the Schafer method was discarded recently in favor of the Holger-Nielsen method there was some evidence presented[1] which indicated that the artificial respiration method did not provide as much pulmonary ventilation as that measured for a conscious resting subject nor was it considered sufficiently adequate, in all cases, to support life. However, in the case of pole-top resuscitation, all investigators agree that its effectiveness in providing ventilation of the lungs is greater than that provided by normal respiration processes or the application of the Schafer method. Furthermore, there is no record of failure to support life in any field or laboratory subjects being provided with manual respiration by this technique. Since there is no indication that the pole-top method is ineffective, the only major factor which can be considered as being substantiation for a change is that the proposed method will be more effective in resuscitating electric shock victims without materially impairing the facility of application.

Unfortunately, there does not appear to be any generally accepted standard for evaluating the effectiveness of artificial respiration following electrocution. In these discussions, volume of air moved by manual manipulation has been used as the measure for determining the effectiveness of various techniques, even though oxygen over and above that required by the physiological condition of the body for the support of life may be supplied. It is questionable whether excess oxygen available, by itself, has the significance normally associated with it, if comparisons are made only with respiratory air requirements of a normal resting subject. If it can be assumed that the functional condition of the organic system and the carbon dioxide concentrations in the blood stream of a normal resting subject is representative of the condition of a body immediately following electrocution, then, as far as the respiratory system is involved, it can be concluded that the oxygen requirements for successful resuscitation are no greater than the oxygen provided by the measured tidal air of the normal resting subject. However if the violent muscular contraction, which is present and sometimes sustained for an appreciable period of time in so many cases of electric contact, results in an appreciable increase

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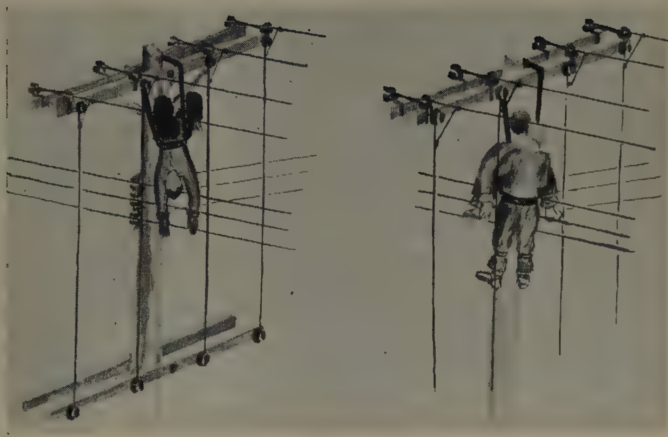

Figure 1. Position of body after release from contact (left). Proximity of wires during resuscitation (right)

in carbon-dioxide concentration, the immediate demand for oxygen may then approach that usually following strenuous physical exertion and the comparison might better be made with a value approaching the measured vital capacity. With this wide range in pulmonary ventilation requirements of 500 to 4,000 cubic centimeters per respiration, it is apparent that a more specific determination of air requirements must be made, even though we only consider the condition existing immediately after the paralysis of the respiratory control centers. If, in addition, the varying rates of carbon-dioxide accumulation during respiratory arrest in inert subjects is considered, the problem becomes quite involved.

Reported data[1] show a reduction of 35 to 40 per cent in the cubic centimeters per minute pulmonary air ventilation of a conscious resting subject when placed under general anesthesia (sodium pentothal intravenously administered). Previous investigations[3] showed that artificial respiration methods moving slightly more air than that measured in a conscious resting state created apneic conditions in some subjects due to oxygen saturation of the blood and correspondingly diminished carbon-dioxide concentration. If these cases are representative of the oxygen requirements of an inert subject, it would appear safe to assume that any method of artificial respiration which will move as much or more air than that measured as the tidal volume of a conscious resting subject will be adequate if applied immediately after respiration arrest and before carbon-dioxide accumulation progresses very far.

In the case of the pole-top method, no data have ever been presented that show less air movement while under manual respiration control than that observed as the tidal volume of the conscious subject. The results reported by the two research groups show increases of 35 and 26 per cent in cubic centimeters per respiration, and 25 and 18 per cent in cubic centimeters per minute above the recorded tidal volume. Apparently there is absent any suggestion of the deficiency (25 per cent reduction) which was such an important factor in the recent considerations leading up to the ultimate displacement of the Schafer method.

Figure 2. Position of body after contact (left). Method used to hold body away from lines and apply resuscitation. Note operator's safety strap fouled under victim's safety strap restricting movement of operator (right)

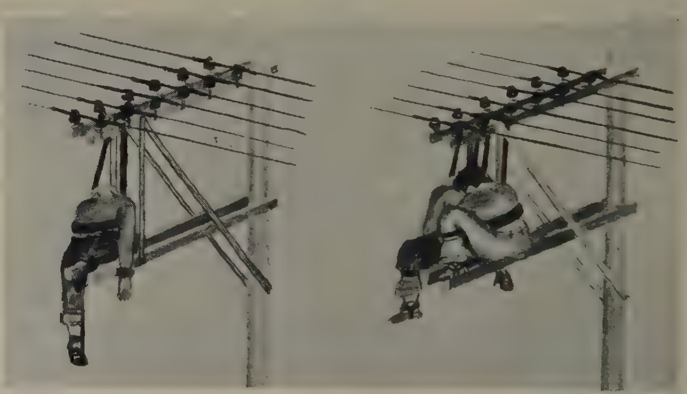

Figure 4. Position of body after contact (left). Position taken by operator to apply resuscitation (right)

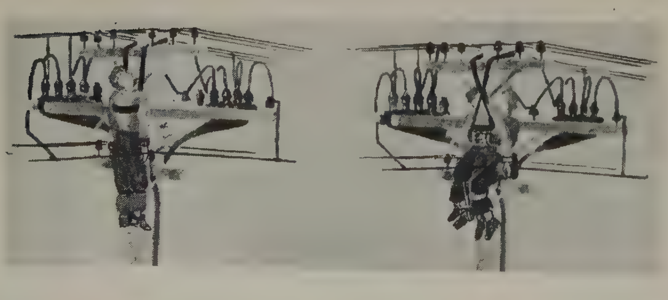

Figure 3. Position of body after being cleared from energized equipment (left). Method used to hold body away from arcing equipment and apply resuscitation (right)

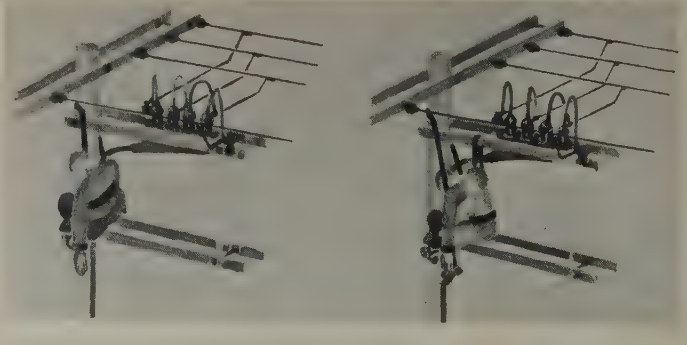

Figure 5. Position of body after contact (left). Position taken by operator, not equipped with climbers, to apply resuscitation (right)

An analysis of the mechanical effect of the Schafer and the pole-top methods may account for the difference in the results obtained. The Schafer method has an active expiration cycle caused by pressure on the back of the prone subject, but it depends almost entirely upon the musculature tone of the thorax for the inspiration cycle. The amount of air expelled is dependent upon the degree of compression of the lungs, and the inhalation volume does not exceed the amount of air expelled. Any action which increases the thoracic volume results in an increased inspiration, regardless of whether this increase was accomplished by an expansion of the chest or an increase in the height or length of the pulmonary cavity. In placing the inert subject in a vertical position, as in the pole-top method, the diaphragm falls to a position below normal thereby causing an initial inspiration and a greater pulmonary capacity than that which would exist in the same subject in the prone position. Upward pressure on the diaphragm causes active expiration in excess of that obtained by back pressure on a prone subject, and during the inspiration cycle, the expansion of the chest and the lungs due to musculature tone is further assisted by the forces of gravity acting on the diaphragm and thoracic content.

If we now tentatively concede that any method which moves the most air is most efficacious in restoring normalcy to the shock victim, we must determine whether the improved method presents problems in application. To be acceptable, the method must lend itself to conditions existing at the precise location where it is to be used. We cannot ignore the fundamental factors in this entire problem which are that the working space is quite limited and fixed, the position of the subject is determined by his working position before electric contact, the length and position of his safety strap, and the final position which his body takes after collapse, and that the operator will be the nearest man regardless of his height or weight as compared to the physical stature of the victim of the accident.

The problem of restricted working space is of extreme importance. A clear horizontal space 24 inches square, free of energized conductors or other obstructions, is usually considered quite spacious. Vertical clearances are usually less, since the safety strap (normally approximately 58 to 60 inches long) if placed over a crossarm and around the pole will hold the victim's head and shoulders close to the conductors on the crossarm, even if the body hangs vertical along the pole and the body belt has moved up under the arm pits. Obviously, in situations like this, no method which contemplates raising or spreading any of the subject's arms or legs can be applied without seriously jeopardizing the recovery of the subject and the life of the operator by additional exposure to contact with energized equipment. See Figure 1.

In teaching pole-top resuscitation, the standard procedure of placing the subject in position on the operator's safety strap is normally used. Stress is placed on the desirability of attaining this position, but attention is called to the importance of applying artificial respiration according to the basic principle if placing the subject in the standard position would result in too much loss of time or

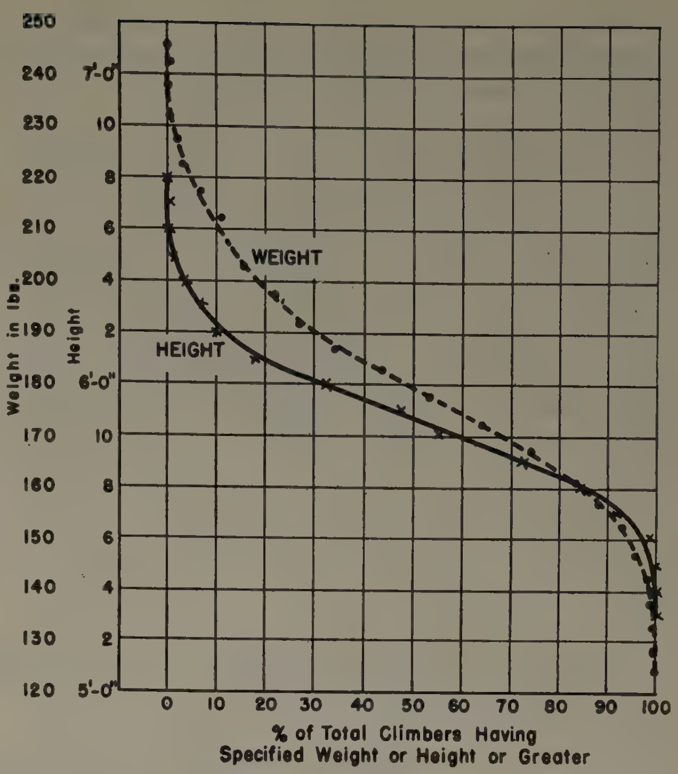

Figure 6. Weight and height characteristics of potential subject and operator for pole-top artificial respiration

appears to be impractical. A review of the seven cases which we have experienced in the last 20 years shows that in only three of them was it possible to place the subject in position in accordance with the standard procedure. In the remaining four cases, the position taken by the operator was varied to suit the conditions. In two of them, Figures 2 and 3, part of the operator's effort was exerted to hold the subject's body away from energized equipment; in another, Figure 4, to hold the hanging body away from arcing equipment and in a position from which manual respiration could be applied; and in the last, Figure 5, the operator was not equipped with climbing tools. It is interesting to note that there is one point in common in all of these four cases, the weight of the subject is supported by his safety strap and body belt while artificial respiration is being applied. This automatically raises the shoulders and expands the chest.

In many cases reviewed, the operator must place himself in a precarious position to apply resuscitation most effectively and obtains stability of position by holding on to the suspended body. This is particularly true if the operator is appreciably shorter or lighter in weight than the subject. When it is realized that our linemen range in height from 5 feet, 3 inches, to 6 feet, 8 inches, and in weight from 124 to 246 pounds, see Figure 6, the difficulties can be visualized that may be encountered by one of the smaller men operating on one of the larger subjects. We have, by actual field trial, assured ourselves of the ability of the small man to apply the present pole-top method properly, but serious difficulties have been encountered by a small man raising and pulling back the shoulders of a large man astride his safety strap.

Before considering any change from present practice in pole-top resuscitation, we believe that it is necessary to be assured that the following points are evident:

1. The present method has been proved ineffective.
2. Greater pulmonary ventilation will increase the effectiveness of the resuscitation technique.
3. Any increase in successful resuscitations due to improved techniques will not be offset by a corresponding decrease in the number of cases where the working space or relative physique limitations prohibit its use.

It is my opinion that the present method has not been proved ineffective; that the proposed method has many limitations in applicability such as space requirements, position into which the subject can be placed, and insufficient stature and strength of the operator when related to the subject; and finally that any improvement in successful resuscitation rate will be more than offset by a reduction in rate due to increased elapsed time, uncertainty on the part of the operator, and injury to the subject by more extensive manipulation.

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Ten Years' Experience With a Completely Electrified Products Pipe Line

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This pioneering extensive petroleum-products pipe line utilized high-speed centrifugal pumps driven by electric motors. In addition all power was purchased from power companies and all communication was handled by the telephone company. The advantages as well as the disadvantages are presented, and suggestions made for further improvements.

During the 1930's, petroleum products sales curves of distributors in the southeastern states indicated such a steep rate of increase that it was evident that the existing tanker-rail-truck distribution facilities would soon be completely overtaxed. A thorough study of this area convinced the group that formed Plantation Pipe Line Company that in all probability an even greater rate of increase in consumption of petroleum products could be expected and that a products pipe line would be the most economical solution to the distribution problem.

It was decided to start the line at Baton Rouge, La., which has large refining capacity, is strategically located near large crude oil producing areas, and is on the Mississippi River so that cargoes destined for entering the pipe line can come in by barge and tanker. Based on the volume to be handled and the then prevailing tanker, rail, and truck shipping rates, an inland line with delivery terminals at or near large distribution centers was indicated. The line was terminated at Greensboro, N. C., since other sources could serve the areas farther north more economically.

In building one of the first extensive petroleum products pipe-line transportation systems, this company's engineers and management were, to a large extent, pioneering. With few exceptions, pipe-line practice at the time was to employ piston pumps powered by slow-speed heavy-duty diesel or gas engines, while this company elected to use high-speed centrifugal pumps driven by electric motors. However, worse still, from a commonly held viewpoint, the pipe-line company was completely at the mercy of the power companies by deciding to purchase all power required. Then, in the opinion of some of the critics, to make certain that the system would be completely unsatisfactory no communication lines were built, the problem being entrusted to the telephone company.

To those whose contact with the oil industry is recent, this undoubtedly is amusing, but there were some deadly serious arguments pro and con only a very few years ago. The authors know of one instance just 5 years ago where the designer of a large crude-oil pipe-line pumping station installed engine-driven pumps to keep from being at the mercy of electric power, even though the pumping station was located almost in the front yard of a large power plant, and in spite of the fact that every barrel of oil handled by the pipe line was gathered and pumped to the pipe-line tanks by electric motors obtaining energy from this same power plant and electric system.

The Plantation pipe line has now been in continuous operation nearly 11 years. It has performed successfully

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and has expanded from an initial capacity of 60,000 barrels per day to a present capacity of 225,000 barrels per day. All of the expansion up to now has been largely a duplication of the original design. Most of the original equipment is still in service and only minor changes in the original station layouts have been necessary.

Communications supplied by the telephone company have proved to be just as reliable, if not more so, than company-maintained lines and considerably more economical. With the exception of one bad hurricane, which would have taken out company lines too, loss of throughput in the pipe line attributable to failure of teletype circuits has been negligible.

With purchased power costing an average of slightly more than 7 mills per kilowatt-hour, with down time due to power failures averaging a throughput loss of less than 1/10 of 1 per cent, and considering the much lower investment and maintenance costs of the electric motor, plus its higher availability factor as compared to the diesel or gas engine, Plantation is still convinced of the superiority of the electric drive. This is not to say that there are no difficulties with the power companies—for instance, for not permitting use of full-voltage starters on 600- and 900-horsepower motors. Reduced-voltage starters cost more and require more maintenance.

It is felt that if the pipe-line company were allowed to furnish the substation instead of the power company, a better looking, better operating, and probably a more economical over-all job could be obtained using the packaged "Unit"-type substation and placing most, if not all, of the switchgear now housed in buildings outdoors in the substation. For example, the company has gone to considerable trouble to separate electrically the two main lines so that they can operate independently of each other, but at the power company's substation, these two separate feeders tie on to one bus, fed by one bank of transformers, protected by one set of power company fuses.

However, it is realized that the enormous industrial expansion taking place in the south and southeast, together with the critical shortage of power generating and distributing equipment, keeps the power company engineers very busy trying to keep up with the electrical demand. They have their problems too, and in all fairness, it must be said that they so far have never failed to supply the pipe-line company with dependable power in the amount requested, and on the date required.

Plantation now has one 12- and one 18-inch line from Baton Rouge to Bremen, Ga., where all products go into tankage, and one 10- and one 14-inch line from Bremen to Greensboro, N. C. Gasolines are usually handled in the 18- and 14-inch lines and fuels in the smaller lines, although this procedure can be, and occasionally is, reversed. Pumping stations are at approximately 60-mile intervals on the 12- and 18-inch lines and 50-mile intervals on the 10- and 14-inch lines. Each station contains three 900-horsepower (with space for a fourth unit) pumps on the 18- and two 900-horsepower pumps on the 12-inch line, three 600-horsepower and two 600-horsepower pumps, respectively, on the 14- and 10-inch lines. Pumps and control gear for both lines are in the same building.

Branch lines from the main system extend from Helena, just south of Birmingham, to Montgomery, Ala.; Bremen, Ga., to Chattanooga and Knoxville, Tenn.; and Bremen to Macon and Columbus, Ga. During World War II (before construction of the new 18- and 14-inch lines), intermediate stations at 30-mile intervals on the 12-inch and 25-mile intervals on the 10-inch main line were operated. These are now shut down, but ultimately they will have to be started up again as the demand for petroleum products continues to increase.

At the present time, Plantation is working on four new pumping stations, which will be unattended and remotely controlled. Two of these are small, each with a 300-horsepower vertical centrifugal pump to handle around 7,500 barrels per day at 1,200 to 1,400 pounds pressure—one at Clanton, Ala., on the Helena-Montgomery 4-inch lateral line, and the other at Franklin, Ga., on the 4-inch lateral line between Bremen and LaGrange. Control of the Clanton station will be from Helena and of the Franklin station from Bremen, in both instances the control consisting only of simple start-stop by means of dialing impulses over the existing teletype circuits, with no telemetering or supervisory control indications. The operator at Helena will have to judge what the unattended station at Clanton is doing by watching flow and pressure instruments on this line at Helena.

All possible safeguards are being incorporated to shut down the unattended stations if trouble develops, including a way to shut down remotely with the teletype circuit out. This is accomplished at Clanton, for example, simply by reducing the flow at Helena. At the unattended station a low flow contact on a flow meter energizes the stop circuit of the main motor. This low flow contact is interlocked with a limit switch on the pump discharge valve to render it inoperative except when the valve is fully open. The automatic shutdown devices are grouped into two classifications, (1) those that prevent the station from starting only as long as an abnormal condition exists and (2) those that lock out the station and require manual reset. The operator at the control point will be able to tell from his flow and pressure instruments at the start of the line whether the intermediate unattended station is operating properly, but he will not know what shuts it down. All he can do is to try to restart it once or twice and if it fails to start, send a serviceman out to find out what has happened.

These two stations are experimental from the company's viewpoint, and even though they are of small capacity, it is possible that it may be necessary to add supervisory control later, but they were designed so that this can be done easily, either over leased wires or microwave radio.

On the 8-inch lateral line from Bremen to Knoxville, unattended intermediate stations are being constructed at Armuchee, Ga., and at Athens, Tenn., each with one 600-horsepower horizontal centrifugal pump to handle approximately 30,000 barrels per day at 1,000 pounds pressure. They will have supervisory control and telemetering so the remote operator at the control point, Bremen for the Armuchee station and Jersey for Athens, will know almost everything going on at these stations.

This 8-inch lateral line duplicates, on a small scale, conditions similar to those prevailing on the main line. As previously stated, the intermediate stations on the main line that are now shut down ultimately will be put back in service, and if practical, they may be made remotely controlled. Therefore, the unattended stations now being constructed on the 8-inch lateral line have been made as foolproof as possible to gain experience for later use on the main-line stations.

Microwave radio is being employed to transmit supervisory impulses and telemetering functions between the unattended stations and the control points, and one communication party line circuit will be carried all the way through from Bremen to Athens, Tenn. Originally, it had been planned to take the microwave on in to Knoxville, with more voice and teletype circuits and a complete very-high-frequency coverage to mobile units in service cars and trucks, but it was decided to defer part of the program pending further study. Microwave equipment is expensive, and on this installation it would have been somewhat more economical to have leased voice circuits from the telephone company and installed channel deriving or multiplexing equipment on one of them for the supervisory control and telemetering functions. However, as stated before, what is being installed on the 8-inch line installation is being used experimentally for the main line and there is a good probability that sufficient channels will be required on the main line to make microwave economical as compared with leased wires.

It may be different next spring when these unattended lateral line stations are put in operation, but now remote control of not only individual stations but ultimately, perhaps, entire pipe-line systems seems quite feasible.

On the basis of the authors' combined experience of nearly 50 years in the oil business, some observations about the pipe-line business are given.

However, if the impression has been created by enthusiasm for the direct motor-driven centrifugal pump that the piston pump and diesel engine drive are on the way out, it should be dispelled. Pipe lines, like power plants, factories, and so forth, are designed to fit a specific set of conditions. When viscous fluids are handled, the efficiency of the centrifugal pump is so poor that the piston pump must be used. In regard to engine versus electric motor drive, this is still a question of economics, pretty much the same as whether to generate electricity by water power, coal, gas, or waste products. Gas turbine drive, particularly of centrifugal pumps, cannot be ruled out either. Cheaper, more efficient high-head centrifugal pumps can be built for speeds above 3,600 rpm, and the turbine speed easily can be varied to suit volume requirements. There even may be a possibility of using waste heat from the turbine to heat the fluid pumped in the pipe line, which would certainly be advantageous on the more viscous oils or products.

Most electrified pipe lines, and Plantation is no exception, are overpowering to the average pipe-line employee who has no electrical background. The control desk is usually filled with a lot of electric instruments and light indications of little or no interest to anyone except the electrical maintenance man. The electric control panels and even switchgear are in or directly adjacent to the station control room, with warning signs prominently displayed. When one begins to study a control diagram, he finds a relay to perform a given function, then another relay to trip if the first one does not work, and frequently a third one to operate in case the first two fail. A multitude of auxiliary relays are used because pressure switches, limit switches, and other devices do not have enough contacts or do not have contacts of sufficient current-carrying capacity. The general impression created is that either dependable equipment is not available or that the designing engineer was partial to relays. It is evident that designers have not taken advantage of what can be and what should be done with electric equipment, they have simply extended old-fashioned central station design over into the pump room when it does not belong. The average pipe-line pumping-station operator has no electrical background, is not the least bit interested in anything but the pumps and station throughput, and usually is very much afraid of electricity.

The electrical manufacturers today have control gear available that, if properly applied, is thoroughly dependable and will perform day in and day out without a fault. In designing new pump stations, this fact should be taken advantage of so that the electric equipment be installed out of sight and out of the way, leaving nothing for the operator to concern himself with except a few push buttons and the essential indicating lights. For an all-electric station there is really no valid reason why the motor starters, control gear, or even the control desk have to be in the same building with the pumps. To make such an installation with all explosionproof equipment is out of the question because of cost. To cut the building up into rooms, using explosionproof equipment only in the pump room, and trying to keep vapors out of the other rooms by means of pressurizing fans, sealing of conduits from hazardous to nonhazardous areas, and so forth, is also expensive as well as dangerous. Some electrician will forget to put compound in one of the seal-off fittings, or the operator will become overheated and open doors or windows, or the power will fail about the time there is a bad product leak and vapors will get into the control room while the pressurizing fan is down—in short, too many things can nullify the best efforts of the design engineer. A much safer job from the standpoint of removing the element of human error would be to make a separate building of the pump room and then place the control desk, switchgear, office, and other facilities in another building located out of the hazardous area. Some or all of the switchgear, depending on type used and climatic conditions, might be located out of doors in the substation.

The modern electric pumping station usually is almost completely sequenced in starting and stopping and is fully protected against damage from unusual conditions or equipment failures. The operator has little to do other than push buttons and watch instruments, unless the station is also a receiving or delivery terminal. An electric station which merely boosts the product along down the line lends itself readily to initial design for, or later conversion to, remote control.

Pneumatic Mechanisms for Power Circuit Breakers

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PNEUMATIC OPERATION of power circuit breakers, which started before 1900, was used very little until the last decade. The increasing energy required for closing circuit breakers of higher and higher rating, and the demand for quicker closing and reclosing, enhanced the advantages of the pneumatic mechanism and led to its present predominance in the operation of large power circuit breakers. Experience gained with the mechanisms which pioneered the applications and gained widespread use have guided the development of a new line of devices to meet modern requirements of circuit breakers over the voltage range of 230 to 14.4 kv, interrupting capacity range from the highest down to 500 megavolt-amperes, and interrupting times of 8, 5, and 3 cycles.

The outputs of the two mechanisms which cover the range of applications are controlled by varying the pressures in the air supply systems and by throttling the air during the early part of the closing stroke. Compressed air for the operating cylinder is controlled by a single pilot and control valve which admits air when the pilot is energized and exhausts the air as soon as the pilot is de-energized.

These mechanisms are mechanically trip-free so that the opening performance of circuit breakers operated by them is entirely independent of the air pressure existing in the compressed air system. Trip-free operation of these mechanisms is obtained by connecting the pull rod to the piston through two links kept in an inverted toggle position by a linkage which can be released by a trip coil.

When there is no air pressure in the operating cylinder, the larger mechanism opens nontrip-free which makes ultrahigh-speed reclosing possible as the circuit can be energized as early in the initial opening stroke as desired. These mechanisms have already been applied and tested on a number of types of circuit breakers. One of the circuit breakers requiring multiple high-speed reclosure and using the larger mechanism has been described already.[1] Performance of the smaller mechanism reclosing an 800-ampere 115-kv 5-cycle 1,500-megavolt-ampere oil circuit breaker in 16.8 cycles is shown by Figure 1. Reclosing can start when the piston has been retrieved, the trip-free latch re-engaged, and the latch checking switch closed.

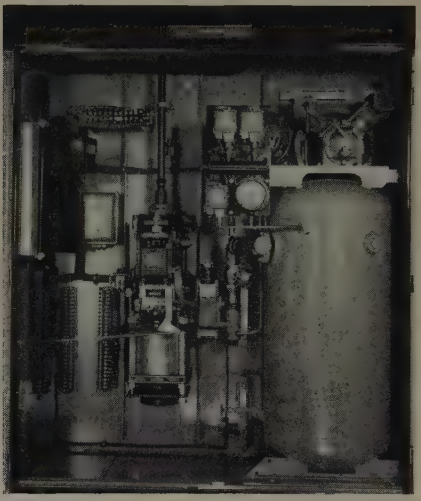

Figure 2. The larger of the pneumatic operating mechanisms for high-speed reclosure of high-voltage power circuit breakers

The operating mechanism and its auxiliaries, such as a control panel for mounting the *XY* relays and knife switches, auxiliary switches, pressure switches, safety valve, compressor unit, heaters, pressure gauge, operation counter, and terminal blocks are mounted inside a sheet metal housing, shown in Figure 2, are made weatherproof and dustproof by sealing the door openings with tubular neoprene rubber gaskets. The equipments' arrangement emphasizes accessibility.

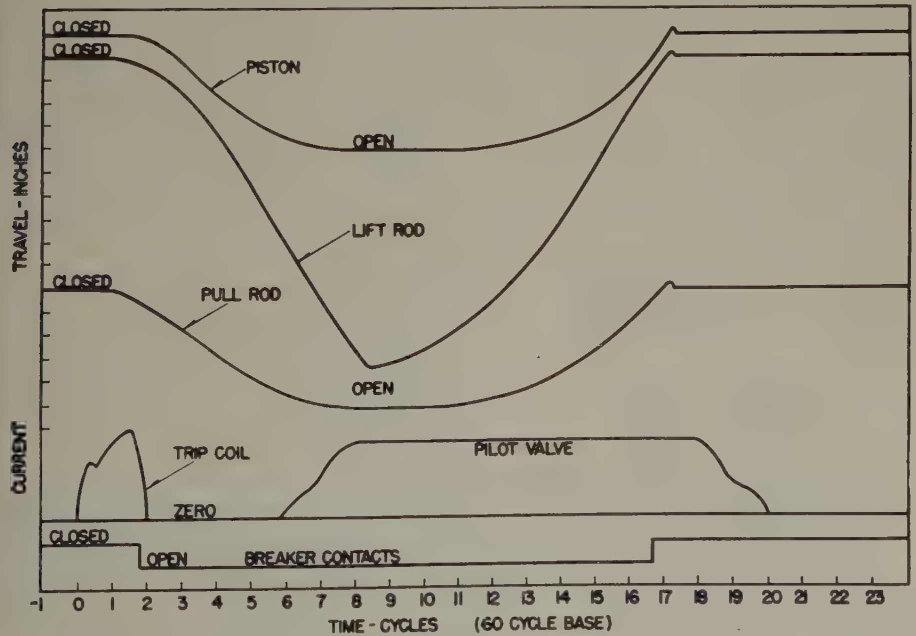

Figure 1. Smaller mechanism reclosing a 115-kv circuit breaker in 16.8 cycles

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Power-Line Carrier for Relaying and Joint Usage–II

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IN ANALYZING the relaying techniques involved in this subject, as distinct from the carrier tools available, we find that there are three recognized principles of carrier relaying, namely: 1. transferred signals, 2. phase comparison, and 3. directional comparison. Any of these principles must be applied with attention to the local conditions under which it must function. By inattention to detail design, trip and control circuits have been known to hold lines, equipment, or protection schemes out of service unnecessarily. Also, the operating personnel may have numerous special features to remember and watch. Such instances, plus random difficulties, can build up antipathy to any type of relaying, carrier included.

Transferred signals often provide line protection, but usually as a by-product to protection of terminal equipment. To extend deliberately the line protection function would require: 1. adequate safeguards against random tripping on spurious signals, 2. assurance that the signal can pass an intervening fault, and 3. more adequate signal initiating relays, particularly for ground faults.

Phase comparison relays require interterminal coordination. For operation during temporary heavy line currents, as in deicing lines, it would be desirable to have alternate high-ratio line-current transformer taps, and means of reading signal strength of remote carrier in the gaps between transmitted pulses.

Directional comparison in its various forms has certain limitations: 1. in regard to the multipurpose use of primary relay elements, particularly where load swings are involved, 2. where spurious ground fault indications may be encountered, and 3. in regard to lines too short for distance relays. The spurious indications may arise from parallel line induction or from various phenomena associated with switching.

The combination of phase comparison, for ground faults, with directional comparison, for interphase faults, was a promising recent proposal.

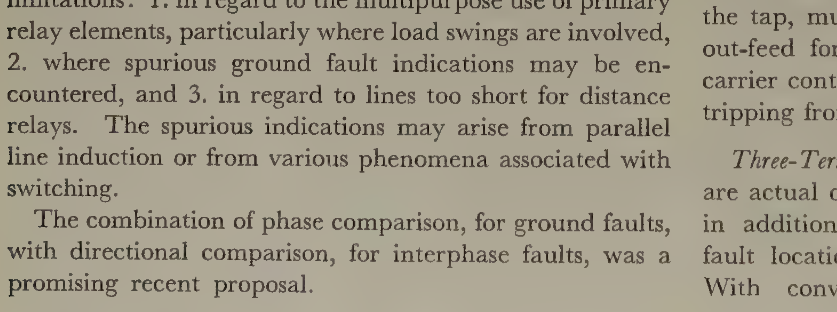

Figure 1. Joint usage by frequency inversion. V_T—Voice (or other nonrelay service) transmitter. R_T—Relay transmitter. R_R—Relay receiver. V_R—Voice receiver. R_C—Relay controls (phase or directional comparison). f_1, f_2—Basic carrier frequencies

Joint usages of carrier for nonrelay purposes introduce the control problem of voiding nonrelay transmission during faults, particularly when the local fault current is weak or zero. A remedy, offered in Figure 1, is called frequency inversion. Using only two basic carrier frequencies per line section, it is possible to have phase and/or directional comparison on keyed on-off carrier, and a 2-way communication channel with the audio spectrum entirely free of nonrelay usage.

Multiterminal lines are a growing problem. They can be divided into classes as follows:

Radial Feeders. In the absence of high-tension circuit breakers on the load take-off transformers, an improved means of remote tripping is needed. For urban systems in particular, conventional carrier is impractical, as are most pilot-wire schemes.

Tapped Subtransmission Lines. The line is tapped to a load take-off through a step-down transformer. It is possible to omit a high-tension circuit breaker on the tap transformer by the use of various expedients such as grounding switches, fuses, remote tripping to the main terminals, and so forth.

Tapped System Trunks. The load take-off transformer in this case will have a high-tension circuit breaker, but the line must be cleared quickly to permit high-speed reclosing to maintain a synchronous tie. All terminals, including the tap, must be opened quickly. Often the tap has an out-feed for some faults on the protected line. Special carrier controls should be installed at the tap, and remote tripping from the main terminals is needed.

Three-Terminal System Ties. In this case all terminals are actual or potential sources of heavy fault current, but in addition at least one terminal, for certain internal fault locations, may have a weak feed or an out-feed. With conventional phase or directional comparison carrier relaying, sequential tripping is inevitable. This may not permit adequate high-speed reclosing.

With a few exceptions, the foregoing problems are common to either carrier or microwave transmissions. If there are no undiscovered principles, a search should be made for different techniques in both fields.

Digest of paper 52-183, "Power-Line Carrier for Relaying and Joint Usage—Part II. A Survey of Modern Power-Line Carrier Systems," recommended by the AIEE Committees on Carrier Current and Relays and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Built-Up Mica Plate for High-Temperature Applications

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Certain developments in the field of built-up bonded mica products for use as electrical insulation are described with emphasis placed on high-temperature applications.

THE IMPORTANCE and, in many cases, indispensability of mica as an electrical insulating material is well recognized. While the term "mica" is applied mineralogically to a group of minerals characterized by a perfect basal cleavage, that is, they can be split readily in one direction into a great number of thin, tough, elastic laminae, the micas most commonly used for purposes of electrical insulation are muscovite (white mica) and phlogopite (amber mica). Chemically, the micas are complex silicates of aluminum with potassium, magnesium, and other elements. Physically, the micas have a hardness of 2–3, an index of refraction of 1.5–1.7, and a melting point of 650–875 degrees centigrade, although they dehydrate to an amorphous powder rather than melting in the ordinary sense.

The importance of mica's use as an electrical insulator and dielectric lies in its extremely high insulation resistance and dielectric strength, its resistance to changes in temperature up to red heat (400–700 degrees centigrade), its complete resistance to the action of water and of oils, and its excellent mechanical characteristics.

In nature, mica occurs in "books," Figure 1, consisting of a number of layers or laminae which can be split readily and separated along the basic cleavage lines into thicknesses of less than 0.0005 inch. When books are reduced to thickness of about 1/8 inch they are known as "blocks," Figure 1, and when further reduced to thin laminae they become "splittings." The thickness of the splittings runs from 0.0006 to 0.0013 inch. Raw mica sheets are limited in size, so that raw mica is adapted to special applications requiring only small pieces such as in vacuum tubes, small capacitors such as those used for radio, sound diaphragms, and airplane-motor spark plugs.

Raw mica in sizes required for most applications is scarce and costly, and the cost is further enhanced by the amount of hand labor required to split to proper thickness and to punch each individual piece, as well as by a large amount of waste involved in its processing. Accordingly, for most applications, mica is used in the form of built-up bonded mica plate, which consists of layers of mica splittings bonded with desired types of bonding agents and the assembly suitably processed. The laminae in the block are split, sorted, and classified according to their approximate areas. Although there have been many attempts to do this splitting by machine, this has been found to be far from satisfactory since machines tend to fracture and break the splittings, and the wastage is high. Splitting, as well as the accompanying sorting and classifying, can be accomplished most satisfactorily by hand labor, so that most mica used in the United States comes from countries having adequate mines and low labor costs. Most of the muscovite comes from India, but a small amount comes from South America, whereas phlogopite comes from Madagascar and Canada. There is a limited supply of muscovite in the United States, but the economy of mining and splitting prevents its wide use as a source of blocks and splittings.

Phlogopite has a disintegrating temperature of approximately 875 degrees centigrade (1,607 degrees Fahrenheit), considerably higher than that of muscovite, and is also much softer than muscovite.

Electrical insulation in the form of built-up bonded mica plates has been classed as Manufactured Electrical Mica.[1] The process consists chiefly of distributing the mica films as uniformly as possible by hand or by a machine and simultaneously applying the binder between layers. The type of binder is determined by the service for which the finished plate is to be used. For low-temperature applications such as commutators, insulation for electric-machine windings, and insulation between switch parts, organic binders such as shellac and synthetic resins of the phenolic and alkyd types are in common use. Also, recently, silicone compounds which can withstand a considerably higher temperature than the foregoing resins, have come into use as a binder. Some applications require a flexible plate which, for example, can be wrapped around windings, in which case a plasticizer is incorporated with the resin to impart flexibility. The plate also may be made thermoplastic for molding, as is done with commutator rings, or it may be thermoset, which is necessary for commutator

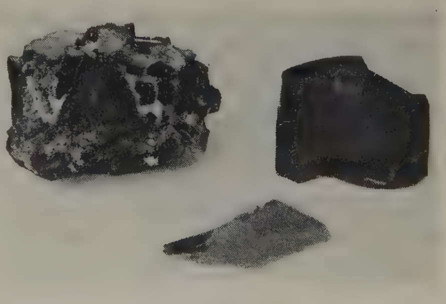

Figure 1. "Books" and "blocks" of mica in natural state

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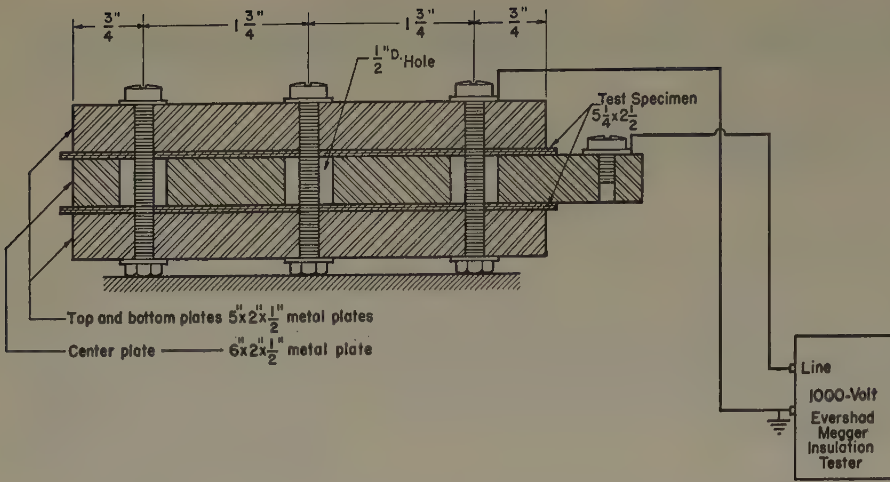

Figure 2. Apparatus used for high-temperature resistance tests

segments. The electrical characteristics of the finished plate are in a substantial measure determined by the electrical characteristics of the binder.

In the process of manufacture, the solvent of the binder which has been applied to the loose splittings is removed in a heated oven, and the plate is then subjected to pressure between heated platens. When cooled under pressure, a hard smooth plate results. In most cases this plate is milled between sanding rolls to produce greater uniformity of thickness. The foregoing processes, which have been in use for years, are applicable to plates which are to be used at low temperature.

The rapid development and expansion in the uses of electric heater appliances during the past few years has required a mica plate which could withstand red-heat temperatures such as are necessary for resistors, space heaters, toasters, flatirons, sandwich grills, and other high-temperature appliances. For most of these applications natural sheet mica is well-suited, but the cost of pieces large enough to be of use would be prohibitive and the available supply would meet only a small fraction of the demand. This has lead to the development of High-Heat Mica Plate[2–5] in which the mica films are bonded together by an inorganic binder into plate form which is suitably processed to produce a high-temperature-resistant mica-insulating material.

This type of mica plate must possess high mechanical strength, close thickness tolerances, durability, and high insulation resistivity, both surface and volumetric, at both high temperatures and high relative humidities. The plate also must possess a high degree of mechanical hardness and integration to permit free punching, notching, and element winding. In addition, the plate must also resist the action of water and water vapor to assure the mechanical integration and electrical resistivity of the insulation under these conditions.

The foregoing characteristics are in large measure determined by the binder, although the process of manufacture is also highly important. Thus, while in the process of manufacture of the mica plate it is necessary that the binder reach a state of flux at a temperature just below the dehydration temperature of the mica, it is also essential that in service the binder remain substantially in the solid state when the plate is subjected to temperatures somewhat below the dehydration temperature of the mica. Hence, the temperature range in which the binder passes from the solid to the molten state is critically narrow. Other requisites of the binder include high adhesion to the mica surface, low hygroscopicity to assure minimum surface leakage under conditions of high relative humidity, negligible electrolytic conductivity at operating temperatures, resistance to deterioration in atmospheric exposures including high relative humidity, and chemical inaction upon the resistor wire. The binder also must have a low coefficient of expansion, not greatly different from that of the mica itself, up to and including the temperature of redness, in order to prevent cracking and buckling of the mica plate when it is heated to red heat and cooled under pressure in manufacture, and also when it is used in appliances. A study of inorganic chemical compounds shows that only a few have even the requisite melting-point characteristics, and only a small part of these meets all the requirements of an operable high-temperature binder. Furthermore, so far we have been unable to find any one compound which meets all of the necessary requirements. Accordingly, it is necessary to combine two or more compounds, each of which imparts some of the required characteristics to the plate. Fortunately, it is possible to employ higher-melting-point salts by utilizing the eutectic behavior of mixtures whereby the melting point of the mixture can be brought within the desired temperature range to produce highly satisfactory plates.

Among the chemical compounds which have possibilities as a binder is boron trioxide (B_2O_3) which has a melting point of 577 degrees centigrade and already has been used alone as a binder for mica films. It has several desirable characteristics such as a melting point near the critical value, good adhesion, and the important property of high electrolytic resistivity, as well as high resistivity at high values of relative humidity. However, on continued exposure even at ordinary relative humidities it soon crystallizes by reversion to boric acid, and plates bonded with it undergo rapid physical disintegration. Hence its chemical instability in the presence of moisture prevents its use alone as a binder for mica plate, but when used in combination with other salts it does impart its high-resistivity properties to the finished plate.

The alkali metal metaphosphates also have good possibilities as ingredients for binders. They have melting points near the critical value and have a high degree of adhesion, thus producing a strong plate mechanically, and they do not readily crystallize on continued exposure to moisture. However when used alone, they do not produce in the plate sufficiently high values of electrolytic

resistivity and resistivity at high humidities to meet present-day specifications.

Combinations of alkali metal metaphosphates and fused alkali metal borates are highly resistant to the action of water vapor, and plates bonded with these salts have the necessary physical and chemical stability to retain structural integration and mechanical strength after continued exposure to high relative humidities. However, plates bonded with such binders share the same limitations as those of alkali metal metaphosphates.

By incorporating boron trioxide in the combination of alkali metal metaphosphates and fused alkali metal borates it is possible to increase the resistivities to satisfactorily high values, and yet produce a plate which not only can resist disintegration in the presence of moisture, but retains its mechanical integration even when immersed in water as tests cited later show. For example, a test plate bonded with the fusion product of 1 part potassium dihydrogen phosphate (KH_2PO_4) and 4 parts sodium tetraborate ($Na_2B_4O_7 \cdot 10H_2O$) had a resistance of 0.030 megohm at 648 degrees centigrade. By replacing 1 part of the sodium tetraborate with boron trioxide the resistance was increased to 0.193 megohm, or more than six times the initial value, and by replacing 3 parts of the sodium tetraborate with boron trioxide, to 0.311 megohm, or over ten times the initial value.

In these various inorganic binders it is our belief, substantiated by physical and chemical behavior, that the fused binder compositions are chemical reaction products of the borophosphate type, analogous to the borosilicate glasses, rather than purely mechanical mixtures of fused salts.

The quality of the completed plate is dependent also on the manufacturing process, the temperature of fusing the binder composition, and the pressure and time of cooling.

In the process of manufacture, mica splittings for the high-temperature plate are laid in almost the same manner as for the low-temperature or organic-bonded plate, with emphasis on thickness uniformity to prevent high and low spots, and with caution in application of the solution of binder salts to restrain the deposition of binder on the outer surfaces which would be deleterious to the surface resistivity of the finished plate, particularly when the humidity is high.

After the binder solvent has been removed in a drying oven, the process consists essentially in heating the so-called "green" plate to a temperature sufficient to bring the binder to a state of flux and then compressing and cooling it under pressure. The material then may be fabricated into resistor cards and other insulating parts.

ELECTROLYTIC CONDUCTION

The foregoing chemical compounds, found to be the most suitable for use as binders, flux in the range of dull red to dark cherry temperatures. It is recognized that all salts to a greater or less degree become electrolytically conductive as they approach or become molten. Thus, the range between the temperature required for fluxing the salt and the temperature to which the already-fluxed binder may be subjected in service is accordingly narrow and critical. Although the average temperature to which the mica insulation is subjected in operation may be well below the melting point of the binder, the resistor wires themselves usually operate at red-heat temperatures well above the melting point of the binder, and hence there will be local hot spots where the wires come in contact with the insulation, and some of the local areas of the plate may readily become conducting. This in turn produces leakage currents between sections of the resistor wire. Also, many appliances are subjected to high-voltage tests which are made at temperatures which are well above those of normal operation. Obviously under these conditions, any electrolytically conducting areas become a source of dielectric weakness, that is, arc over to the grounded metal may occur even though conduction through these areas is small.

In determining the leakage characteristics of the material, the apparatus shown in Figure 2 is used. Test samples are clamped between metal plates. Three plates are used so that two samples connected in parallel are tested simultaneously, the two samples being from the same mica plate. The top and the bottom plates are connected together by the clamping bolts. Experiments have shown that under these test conditions at high temperature the surface leakage is negligible compared with the conduction current through the specimen, so that no guard electrodes are necessary. This is due to the fact that the surface area

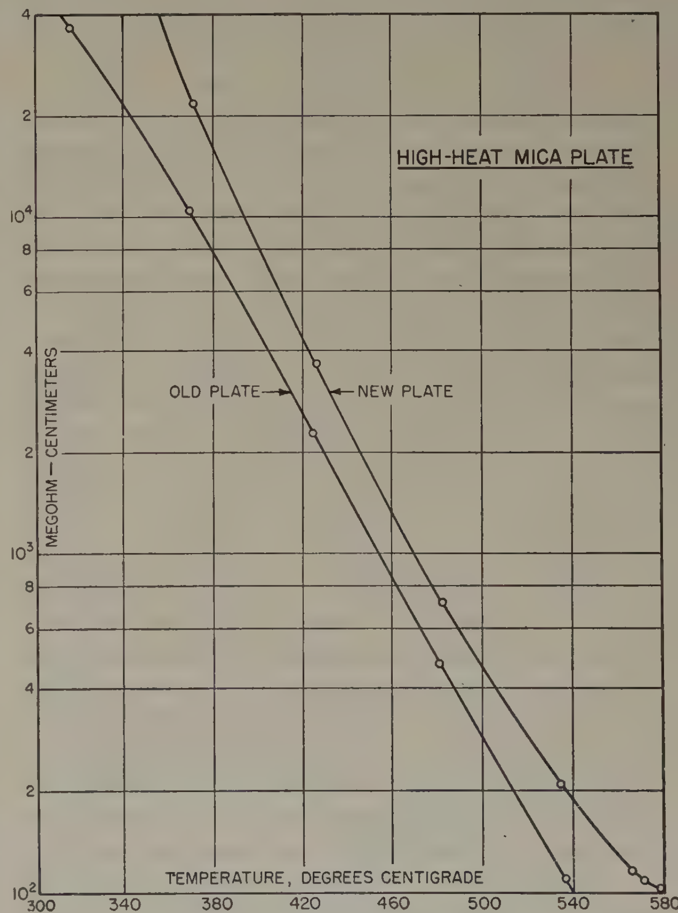

Figure 3. Effect of temperature on insulation resistivity

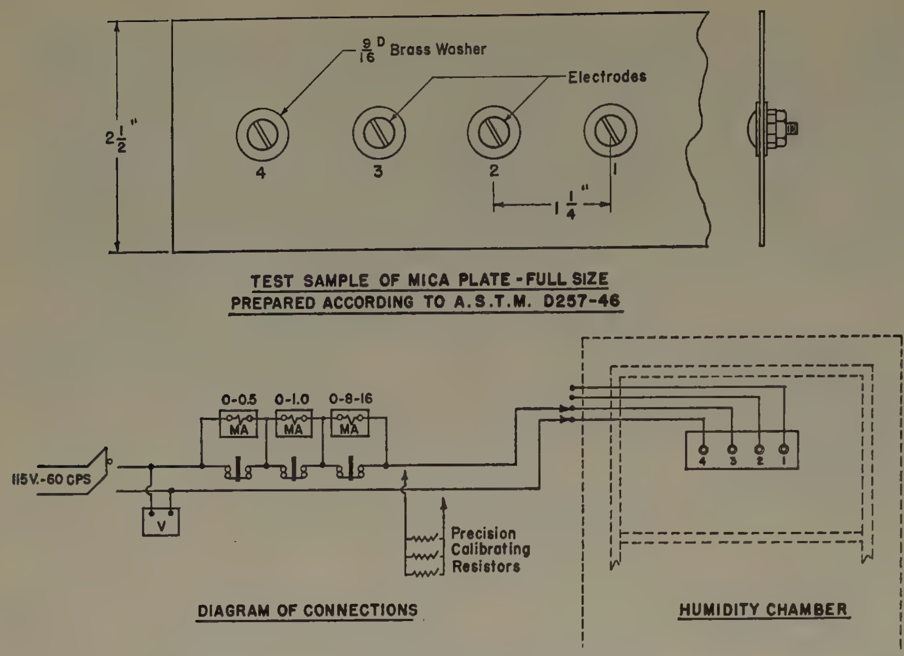

Figure 4. Apparatus for humidity resistance tests

of the metal plates in contact with the mica sample is large, and the length of the conducting path is very short compared with the effective area and length of the leakage path, which consists of the projecting edges of the sample. The resistance is measured with a 1,000-volt Evershed Megger Insulation Tester.

The curves of Figure 3, obtained with the apparatus shown in Figure 2, show the progress which was made in one series of experiments directed towards increasing the electrolytic resistivity of the binder at high temperatures. Resistivity, in megohm-centimeters, is plotted logarithmically as a linear function of temperature. The left-hand curve, designated Old Plate, shows the resistivity characteristics of a plate bonded with a mixture of an alkali metal metaphosphate and an alkali metal metaborate, and the right-hand curve, designated New Plate, shows the characteristics of a plate bonded with an alkali metal metaphosphate and an alkali metal metaborate with boron trioxide added.[4] However, the improvement was not just a matter of adding boron trioxide, for the addition of this salt makes it necessary to adjust the proportions of all the constituent salts so as to obtain simultaneously high mechanical strength and resistance to moisture, as well as high electrolytic resistivity.

It will be noted that with each curve the resistivity drops rapidly, approaching a low value at the higher temperatures, but that while the resistivity of the so-called Old Plate ultimately dropped nearly to zero, the resistivity of the New Plate reached a constant value of practically 100 megohm-centimeters, which is attributable to the incorporation of the boron trioxide component in the binder. Although this value of resistivity may appear low, with the geometry of the usual resistor element and at the usual operating voltage of 115 volts, the leakage current due to electrolytic conduction at high temperatures seldom exceeds a fraction of a milliampere.

With all of the inorganic binders tested, the resistivity is essentially infinite below 260 degrees centigrade as measured with the 1,000-volt Evershed Megger Insulation Tester. When this temperature is reached, the resistivity begins to drop and thereafter continues to drop rapidly as the temperature is further increased, as shown by the curves in Figure 3.

A study of Figure 3 shows that there is still some margin whereby the resistivity at the higher temperatures could be increased. This could be accomplished, in part at least, by using a binder salt having a higher melting point, but the dehydration temperature of the mica itself constitutes an ultimate limiting factor to the use of higher-melting salts as binders. For example, the temperature required to convert potassium dihydrogen orthophosphate to the glassy potassium metaphosphate is 807 degrees centigrade, which is far in excess of the dehydration temperature of muscovite mica, namely, 650–675 degrees centigrade. Similarly, a higher resistivity at elevated temperatures might be accomplished by the use of a binder salt which exhibits specifically high values of electrical resistivity per se at such elevated temperatures, but such a salt at the same time may show increased hygroscopic tendencies, and thus introduce a conductivity due to high relative humidity. For example, boric acid anhydride exhibits high electrical resistivity at elevated temperatures but on the other hand it is insufficiently resistant to the action of water or water vapor to provide adequate electrical resistivity under such conditions of exposure.

SURFACE RESISTIVITY TESTS

Electrolytic conduction of the binder affects not only the volume resistivity, but also the surface resistance. Surface resistivity is important, particularly in those types of heater resistor design in which the mica cards are supported at the ends, as in toasters. The resistor wires which are in contact with the mica card usually operate at red heat, and they may be in close proximity or even in parallel with grounded metallic parts, such as metal clips and metal supporting parts.

These wires produce high local temperatures, which tend to cause electrolytic conductance. It is obvious that under these conditions, leakage currents are determined almost entirely by surface rather than by volume conductance as in Figure 2. Surface electrolytic conductance is often accentuated by the fact that tests for high-temperature leakage may be made at overvoltages which raise the temperature of the resistor wires far above any that are encountered under normal conditions.

Surface-resistivity tests were made in accordance with American Society for Testing Materials Specifications

D257–38, 10 (*c*) and 19 (*a*) and (*b*), in which two circular electrodes are applied to opposite surfaces of the specimen. The tests were conducted at temperatures from 100 to 500 degrees centigrade.

Table I gives results typical of surface resistivity tests. It is found that plates having values which are at least equal to these meet practically all service requirements.

Table I. Surface Resistivity Tests

Temperature, Degrees Centigrade	Resistivity Megohms (Inch-Square)
100	∞
200	8.0×10^4
300	8.0×10^4
400	1.2×10^3
500	0.17×10^3

SURFACE HUMIDITY TESTS

It was pointed out earlier that one of the important properties that built-up high-heat mica must have is high surface resistivity when exposed to high-humidity atmospheric conditions. At the present time leakage-current specifications for electric appliances are very rigid. The appliance is placed in a chamber in which the temperature is maintained at 85±5 degrees Fahrenheit and the relative humidity at 85±5 per cent. After exposure to this atmosphere for 24 hours the leakage current is measured. Many specifications require the leakage current to be as low as 0.2 milliampere under these conditions, while others permit as high as one milliampere.

The testing of the samples to determine leakage under humidity conditions was performed in accordance with Figure 1 of American Society for Testing Materials Specifications *D 257–46* (*1*), the foregoing figure being reproduced in Figure 4 with an extra electrode added. The connections for the test are shown in Figure 4, the three milliammeters being necessary to cover the entire range of leakage current. Alternating current was used. The accuracy of the milliammeters was checked by means of the precision calibrating resistors. Three measurements were made with each sample, one between each pair of the electrodes 1–2, 2–3, 3–4, and the average was taken. In accordance with the specifications for appliances to which reference has been made, the samples were confined in a humidity chamber maintained at 85±5 degrees Fahrenheit and 85±5 per-cent relative humidity for 24 hours and measurements were then taken at frequent intervals. Figure 5 shows the progress that has been made in improving the humidity-leakage characteristics of the plate. Eight typical curves, in which leakage current is a function of time in the humidity chamber, have been selected. These are divided into two general categories.

Curves *1* to *4* relate to tests made on plates bonded with a binder composition comprising sodium metaphosphate and fused sodium borate, and the differences between the individual curves of this series reflect differences in fluxing temperatures, fluxing times, and applied mechanical pressures during manufacture of the bonded mica plate.

Curves *5* to *8* relate to tests made on plates bonded with a binder composition comprising sodium metaphosphate, fused sodium borate, and boron trioxide, and the results show the marked decrease in moisture leakage current of this series numbers *5* to *8*, as compared with the results of curves *1* to *4*. Here again, differences in manufacturing technique are reflected in the individual curves of this series, numbers *5* to *8*. It will be noted that the range of variation between curves *5* to *8*, namely, 0.005 to 0.06 milliampere, is considerably narrower than the range between curves *1* to *4*, namely, 0.012 to 0.30 milliampere. These curves, particularly number *5* to number *8*, illustrate the fact that improvement in the plate is not only effected by the characteristics of the binder itself, but by manufacturing techniques as well. This is well illustrated by comparing the leakage current in curves *8* and *5*.

Another property of the plate is its quick recovery from the high-humidity test conditions which have just been described. With either an appliance or a test sample within a few minutes after removal from the humidity chamber and after being allowed to stand under average room atmospheric conditions, the leakage current drops to so low a value that it is almost impossible to measure it.

It should be noted that while it is most important that the mica insulation possess high insulation resistance, it is essential that precautions in the design and construction of the appliance prevent excessive leakage currents caused by such factors as leakage paths of large cross sections between "line" and grounded parts in close proximity.

WATER ABSORPTION

While it has already been shown that resistance to the action of water vapor is of considerable importance

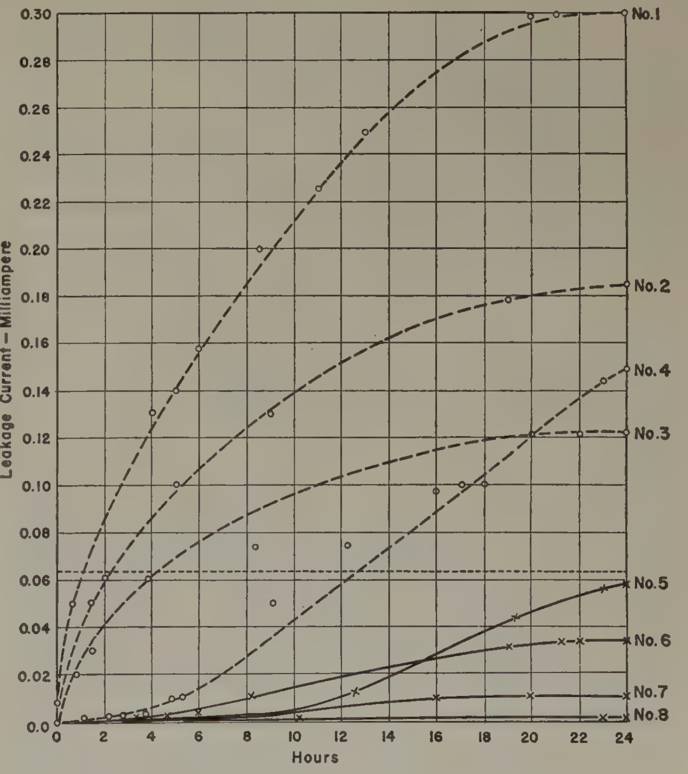

Figure 5. Reductions in moisture leakage current

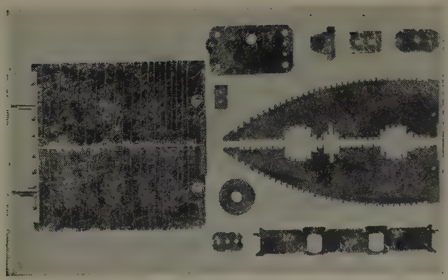

Figure 6. High heat mica punchings: (Left) Toaster element; (right bottom) machine gun punching; (right middle) flatiron core; (others) washers and terminal pieces

in its effect on electrical insulation resistance under conditions of high relative humidity, it is equally important that the material exhibit high resistance to the action of water, in order that it may exhibit adequate durability in the appliance in which it may serve as insulation. Accordingly, water-absorption tests are highly desirable: The test samples, which are 1 inch by 3 inches, are first weighed "as received," then dried for one hour at 105 degrees centigrade, then reweighed to give the "initial moisture content." The samples are then placed upright in a water bath maintained at approximately 25 degrees centigrade, where they remain for a 24-hour period. They are then removed and weighed to give the "per cent water absorption." Table II gives the results of tests made on typical samples.

Table II. Water Absorption

Sample	Thickness, Inch	Per Cent Initial Moisture*	Per Cent Water Absorption**
1	0.010	0.07	2.20
2	0.010	0.10	9.17
3	0.010	0.09	2.93
1	0.015	0.06	2.21
2	0.015	0.05	6.98
3	0.015	0.06	2.43
1	0.030	0.32	9.21
2	0.030	0.08	4.61
3	0.030	0.08	6.78

* After 1 hour at 105 degrees centigrade.
** After 24 hours in water at 105 degrees centigrade.

This type of test is a severe one and experience shows that when the water absorption does not exceed the higher values given in Table II, the life of the plate, when exposed to atmospheric conditions, will be indefinitely long.

DIELECTRIC PROPERTIES

Although the high-heat plate is not ordinarily used where the dielectric properties such as dielectric strength, dielectric constant or relative capacitivity, and power factor are of high importance, high dielectric strength serves to indicate that the plate is well integrated and mechanically sound. Tests are made in sheets taken from stock, and to determine the effect of thorough drying, sheets were subjected to a temperature of 260 degrees centigrade (500 degrees Fahrenheit) for 3 hours and then tested. Four tests were made on each sample before and after drying and the average taken. Average values of dielectric strength under these conditions are given in Table III.

With the 15- and 30-mil plate, drying reduced the dielectric strength. This at first seems anomalous but it is undoubtedly due to the fact that most of the moisture of the undried samples is on the surface and this causes a more gradual distribution of the voltage from the edges of the test electrodes out over the surface, reducing the increased gradient occurring at the rims of test electrodes.

Table III. Dielectric Strength

As Received		After 3 Hours at 260 Degrees Centigrade
Thickness in Mils	Volts Per Mil	Volts Per Mil
10	1,021	1,035
15	936	871
30	738	634

The values of dielectric constant, or relative capacitivity, and power factor have been determined in order to have complete information concerning the product. Typical values of these properties, obtained at room temperature, are given in Table IV, together with the arc resistance.

Table IV. Capacitivity and Power Factor

Frequency, kc per sec.	1,000	5,000	10,000
Relative capacitivity	3.87	3.95	4.16
Power factor, per cent	0.42	0.28	0.33
Arc Resistance, Seconds			
(ASTM, D-495-48-T) "As Received"			196
After 5-day humidity cycle			184

The relative capacitivity is just over half that for natural mica (7.2). Figure 6 shows typical high-heat stampings: a toaster element with resistor wire and clips, flatiron core, washers, and small terminal insulating pieces.

CONCLUSION

It has been the purpose of this article to describe certain phases of development in the field of built-up bonded mica products for use as electrical insulation, particularly in high-temperature applications.

Recently there has been considerable activity in the development of paperlike electrical insulation, sheeted or matted from comminuted mica flakes into the form of continuous, thin, coherent sheets. These roll forms of mica insulation are being viewed as potential substitutes, or replacements, for mica splittings in the various grades of mica insulation.

This field of development has been extensive and rapidly expanding, and it is difficult at this time to evaluate the future import of these products, including their adaption to high-temperature insulation, until more significant test data, as well as performance under service conditions, shall have been ascertained.

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Saturable Reactor With Inductive D-C Load—I

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MEMBER AIEE

TWO MAGNETIC UNITS *A* and *B*, Figure 1, are used as saturable reactors, and the load consists of inductance L_L and resistance R_L. The gate current i_G, flowing through the gate windings *X*1 to *X*2, is discontinuous and flows in rectangular pulses whose amplitude is the same as that of the load current. Thus the average value of the load current I_L is larger than the average value of the gate current I_G.

Due to the current-transformer action of one of the unsaturated cores, ampere-turn equality exists between gate and control circuits, provided low control-circuit impedance:

$$I_G N_G = I_C N_C \tag{1}$$

This fundamental equation is shown by $A'G'OGA$ in Figure 2. The load current I_L follows from equation 2

$$\frac{I_L}{E/R_o} \times \frac{2}{\pi} \text{ arc sin } \sqrt{\frac{I_L}{E/R_o}} = \frac{I_C N_C}{(E/R_o) N_G} \tag{2}$$

and is illustrated by $A'D'B'OBDA$.

Saturable reactors with resistive load have an ampere-turn and power gain which is essentially constant; with inductive d-c load, however, ampere-turn gain and power gain decrease noticeably with increasing control current.

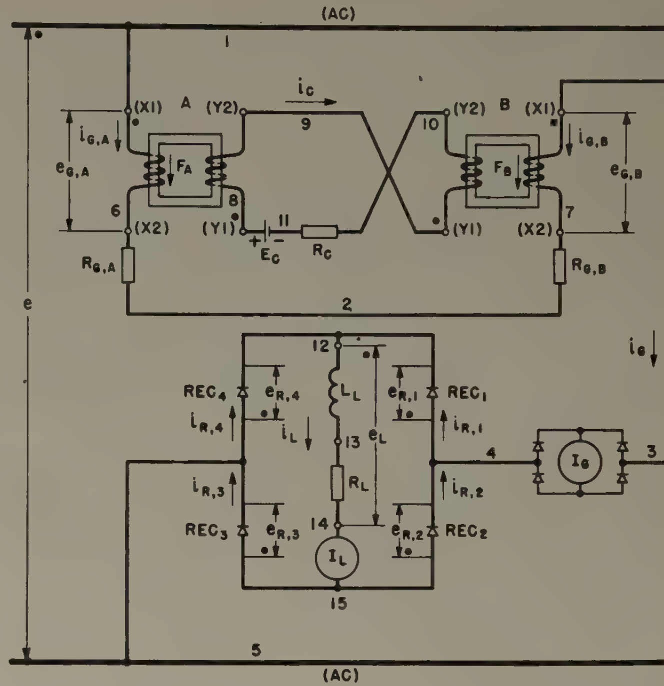

Figure 1. Schematic of series-connected saturable reactor with inductive d-c load

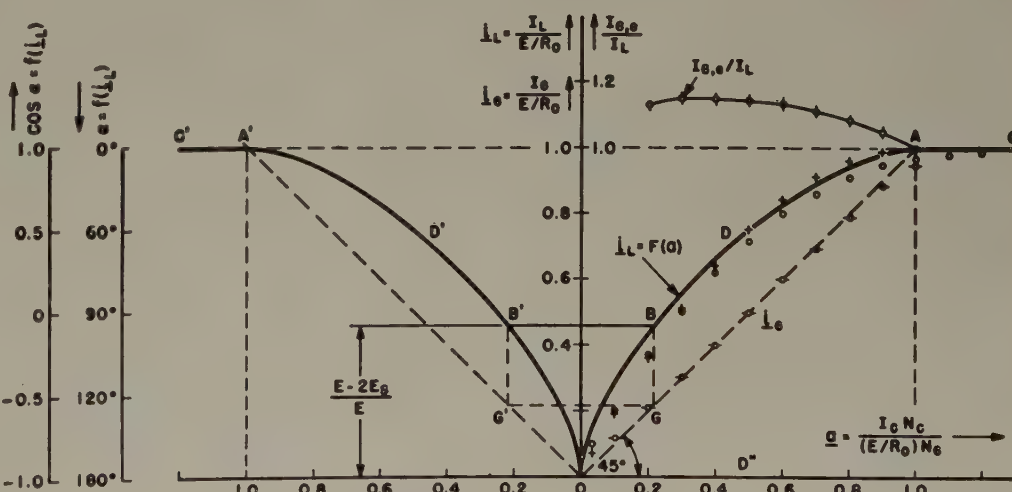

Figure 2. Mastergraph. Load current calculated: C′A′D′B′OBDAC; load current measured: circles with horizontal bars; gate current calculated: C′A′G′OGAC; starting angle α; effective gate current $I_{G,e}$ divided by load current I_L: circles with vertical bars

In contrast to saturable reactors with resistive load having zones where the load current is affected very little by variations of line voltage and load resistance, saturable reactors energizing an inductive d-c load do not have such zones. The load current increases with increasing line voltage and also increases with a reduction of the load resistance. These variations of load current, however, are less than proportional to the variations of line voltage or load resistance.

The reverse voltage on the rectifiers $REC_{1,2,3,4}$ may be considerably higher than the crest of the supply voltage due to overswings caused by resonance phenomena. The latter are contingent on rectifier capacitance. When rectifiers with extremely small capacitances were used, such as germanium point-contact rectifiers or electron tubes, voltage overswings were not observed.

Digest of paper 52-236, "Saturable Reactor With Inductive D-C Load, Part I. Steady-State Operation," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Cable Sheath Surface Discharges and Electric Shock

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ELECTRIC SHOCK HAZARD from the surface of an energized cable is of great importance due to the increasing use of semiconductive jackets. Data were obtained showing the amount of current flowing to ground over a range of "body contact" resistances for nonshielded, metallic-shielded, and "semiconductive" jacketed rubber-insulated cables operating at various voltage levels. The range of currents then was related to known shock sensation levels to assess the amount of hazard involved. A theoretical approach to the voltage rise, surface current, and shock current of cables having different outer surfaces materials helps considerably in understanding the phenomena involved. Calculation of surface voltage rise and current flow can be carried out properly by considering the distributive nature of the cable constants.

1. For small spacings, the voltage rises steadily, almost as a simple power of the surface resistance. For ground ring spacings larger than 6 inches, the voltage rise flattens out considerably at high values of jacket resistance and may even decrease. Ferranti effect is also noticeable.

2. For a given cable, the voltage rises steeply with increase of spacing but the rate of rise decreases at the very wide spacing. The capacity of the cable (kind of insulating material) affects markedly the rate of voltage rise with spacing variation. The greater the specific inductive capacitance (SIC) of the cable insulation, the steeper the rise at low spacings.

3. For a given voltage and spacing class, a given surface resistance produces a higher voltage rise the higher the SIC of the cable insulation. Thus, at a 6-inch spacing the 5-kv cable insulated with polyethylene has a maximum surface voltage rise of 150 volts when the jacket resistance is 10^7 ohms per foot of cable. The same cable and jacket with polyvinyl chloride insulation gives a maximum voltage rise of 470 volts.

4. Under otherwise equal conditions, the difference between the surface voltage rise for the 5- and 7.5-kv class is small, only 10 to 25 per cent greater for the 7.5-kv cable. However for the 13.8-kv class, the voltage rises are more than 100 per cent greater than for the 5-kv class.

Practically no effect of surface resistance on current below a million ohms per inch was noted. In this range of jacket resistance, the current is strictly proportional to ground ring spacing and indicates that up to 10^8 ohms per inch sufficient surface conductivity is present to drain the charging current much like a conductive sheath. Above 10^8 ohms per inch, the current falls off sharply with the increase of surface resistance—the wider the spacing, the more rapid the decrease.

The considerations which influence shielding of the cable from the standpoint of durability or continuity of service may or may not be consistent with maximum safety to personnel from shock. Properly designed semiconductive shields provide an excellent all-around solution, but when improperly used, such low-resistance jackets can be potentially dangerous and present a serious shock hazard.

Tests were made on cable sheathed with a high-resistance neoprene jacket, a low-resistance or semiconductive neoprene jacket, and a metallic shield under a neoprene jacket to determine the current available through a simulated human contact as a function of jacket and ground ring spacing. This current was then related to known shock physiology. There is little doubt that from the standpoint of hazard to personnel, improperly designed and installed semiconductive jacketed cables are potentially more dangerous than those single-conductor cables with a good grade of insulating jacket and grounding intervals greater than 10 inches.

The analysis also indicates that whereas normally the fully metallic-shielded cable is probably the safest in so far as shocking current magnitude on accidental contact is concerned, it is potentially the most dangerous in the event that the shielding becomes separated from ground. Similarly, a nonshielded cable having an extensive ungrounded wet surface can act like a shielded cable with shield separated from ground. Hand contact with a regular neoprene-jacketed cable will pass current through the body proportional only to the hand contact area (assuming low body contact resistances). However, with a conductive neoprene jacket, the current will be proportional not to the hand contact area but to substantially the entire length of jacket between ground rings.

Tests of maximum voltage rise between ground rings or grounding contacts along a jacket do not indicate the potential shocking currents because the voltage rise along an insulating jacket can become very high, sometimes almost equivalent to the conductor voltage. However, the amount of coulombic charge associated with the high voltage is negligibly small so that the current that flows also must be negligibly small. Actually, the high voltage usually is dissipated instantaneously as a sparking discharge and the maximum current that flows when the hand finally comes into actual contact with the jacket surface is equivalent to the charging current available through the insulation over the limited contact area of the hand. With the conductive jacket there is little voltage rise between ground contacts due to the low jacket resistance. However, there is considerable charging current drainage indicating a large amount of stored charge. The high current available makes the cable potentially dangerous.

Digest of paper 52-206, "Surface Discharges From Cable Sheaths and Their Relation to Electric Shock," recommended by the AIEE Committee on Insulating Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in the AIEE *Transactions*, volume 71, 1952.

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Forces in Machine End Windings

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THE ELECTROMAGNETIC FORCES experienced by the end windings of machines during the surge currents of a sudden short circuit can be large enough to cause serious trouble if the windings are not properly supported. Knowledge of these forces is particularly important in turbine-generators, where the increased loading associated with operation at elevated hydrogen pressures and with larger ratings tends to raise the machine forces to ever greater magnitudes. A step-by-step approach to the evaluation of force on any desired portion of the end windings of a machine, with sufficient accuracy for an engineering study, can be made using a method based on the following differential vector equation[1], expressed as a triple cross product:

$$d\mathbf{F}_1=\frac{I_1I_2}{r^3}\,d\mathbf{x}X(d\mathbf{x}'X\mathbf{r}) \qquad (1)$$

where $d\mathbf{F}_1$ is the vector force on element $d\mathbf{x}$ of a conductor carrying current I_1 exerted by current I_2 carried by element $d\mathbf{x}'$ of another conductor. The vector $\mathbf{r}$ is the line drawn from $d\mathbf{x}'$ to $d\mathbf{x}$, scalar r is the magnitude of this vector.

For end windings lying on a cylinder, or on a cone whose angle from its axis is 25 degrees or less, a developed drawing can be made of the projection of the end winding conductors to a cylinder whose diameter is the average diameter of the end windings. The end windings thus depicted will consist of a group of straight coplanar conductors. The force component in the plane of the developed drawing, experienced by any conductor, can be evaluated by summing the component forces due to currents in each of the neighboring conductors. Various simple geometric arrangements can be found to represent the various pairs of conductors. The force on one conductor of such a pair, due to current in the other conductor, can be evaluated by integrating equation 1. The force distribution along a conductor, as well as the total force, can be found by considering the conductor to be composed of several sections and calculating the force on each section. Figures 1 and 2 exemplify the type of such geometric representation and give an equation for the component of

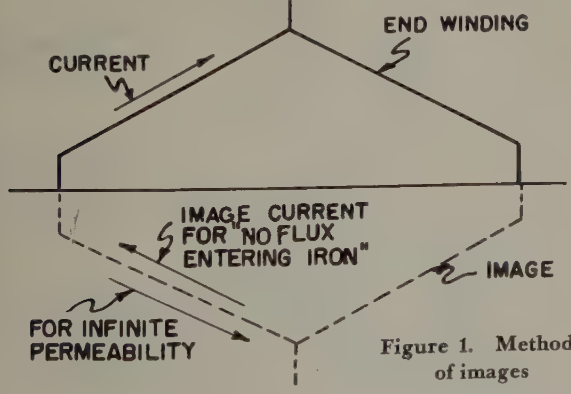

Figure 1. Method of images

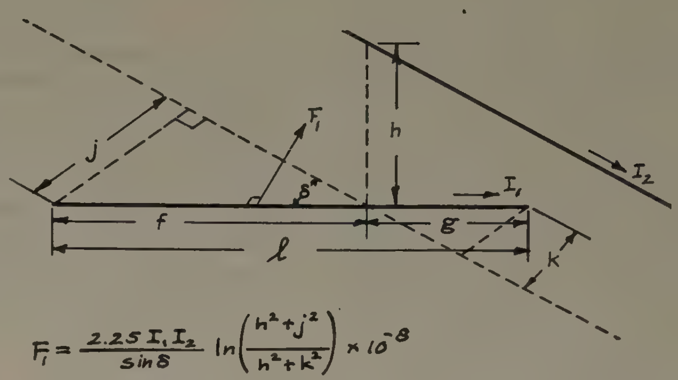

Figure 2. Force due to skew infinite conductor: all cases

force in the direction indicated. The total force could be evaluated by obtaining the component of force in the developed plane of the end windings, and the force component perpendicular to that plane, and performing a vector addition. The latter component of force is, however, small enough to be neglected for most applications.

In analyzing a polyphase machine, the forces associated with the various phase currents can be added to give the total instantaneous force. The equation for the force on a conductor in phase A of a 3-phase machine, for example, would have the following form:

$$F=AI_A{}^2+BI_AI_B+CI_AI_C \qquad (2)$$

This equation gives the force at any instant of time for any possible combination of currents, such as would exist on any type of short circuit. For any 3-phase current distribution not involving zero-sequence currents, the maximum value of force may be found from the following:

$$\text{Total Force } F=\left[\frac{1}{2}\left(A-\frac{1}{2}B-\frac{1}{2}C\right)+\frac{1}{2}\sqrt{\{0.866\ (C-B)\}^2+\left(A-\frac{1}{2}B-\frac{1}{2}C\right)^2}\times \sin\,(2\theta-\beta)\right]I^2\times10^{-8} \qquad (3)$$

where

$$\beta=\tan\frac{A-\frac{1}{2}B-\frac{1}{2}C}{0.866\ (C-B)},\ \text{and } \theta=2\pi ft$$

The method outlined in this article will give results sufficiently accurate for an engineering study of electromagnetic forces in machine end windings.

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The D-C Motor as a Capacitor

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The rotor moment of inertia of a separately excited d-c motor constitutes a true capacitance, capable of resonating with the armature inductance, so the equivalent armature circuit consists of resistance, inductance, and capacitance in series. However, data presented indicate that the armature moment of inertia would have to be reduced radically to render the motors suitable for 60 cycles.

THE ARMATURE OF a d-c machine has, in addition to its resistance and inductance, also a large equivalent capacitance based on the kinetic energy stored in the moment of inertia of its rotor. Although this idea is old, it is not widely known. Ordinarily, moment of inertia is thought of as the mechanical equivalent of inductance, not capacitance; yet it can be shown that under the constraints of the present case, it behaves as a capacitance, and can resonate with the armature inductance. Generally this capacitance has a very large value, many thousands of times as large as the electrostatic capacitance of the winding.

This property of the d-c machine may be made clear as follows: To keep the picture simple, we shall confine our discussion to a d-c motor with the field excited separately and kept constant, independent of the load, and the brushes located at the maximum-voltage position. See Figure 1.

The torque T of such a machine will be directly proportional to the armature current, which is also the line current i:

$$T=k_1 i \tag{1}$$

in which k_1 is a constant of the machine.

Representing the rotational velocity by ω, the instantaneous generated voltage e_G will be

$$e_G=k_2\omega \tag{2}$$

or

$$\omega=e_G/k_2 \tag{3}$$

in which k_2 is another constant of the machine.

Of course, in the armature there will also be a resistance drop e_R, and an inductance drop e_L. The acceleration of the rotor, at no load, will be directly proportional to the torque T and inversely proportional to the moment of inertia J:

$$d\omega/dt=k_3T/J=k_1k_3i/J \tag{4}$$

But by equation 3, $d\omega/dt$ is also equal to $(de_G/dt)/k_2$. Making this substitution in equation 4, and rearranging,

$$i=(J/k_1k_2k_3)(de_G/dt). \tag{5}$$

Equation 5 may be seen to be the same as that of a capacitor current:

$$i=Cde_C/dt. \tag{6}$$

Evidently, $J/k_1k_2k_3$ in equation 5 corresponds to the capacitance C in equation 6, and e_G in equation 5 to e_C in equation 6, so that the separately excited d-c machine exhibits a capacitance C equal to $J/k_1k_2k_3$. In future equations, therefore, we may replace the subscript G by C for all motor (and generator) action type of quantities, using equation 6 to represent the relationship of the line (armature) current to the generated voltage of the machine. The conversion factor $(1/k_1k_2k_3)$ in equation 5 will be determined later.

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EQUIVALENT CIRCUIT

THE COMPLETE equivalent circuit of the machine, including a shaft load, is shown in Figure 2. R_l is the electrical equivalent resistance of the mechanical load on the shaft, R_a the armature resistance, and L the armature inductance.

The load current, if direct current, flows exclusively through R_l, R_a, and L; but if the voltage impressed on the armature is alternating, the current will divide between R_l and C.

The no-load condition, with the field fully excited and the machine freely running, is represented by an open circuit in R_l, that is, $R_l=\infty$. But if it is desired to represent the no-load losses quantitatively, then R_l will be an appropriate high-resistance drawing power equal to those losses.

If the rotor is blocked, then R_l is a short circuit across C.

At all loads, the generated (rotational) voltage appears across C. The terminal voltage of the armature will differ from this by the resistance and the inductive reactance drops.

It may be emphasized that, at constant field strength, the rotational velocity ω of the machine always will corre-

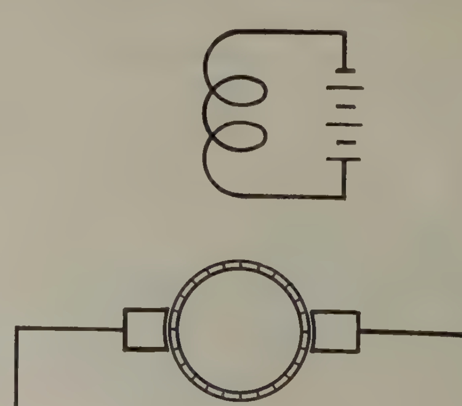

Figure 1. Separately excited d-c motor

spond to the voltage across C. If direct voltage is impressed on the armature, ω will be constant. If alternating voltage is impressed on the armature, ω will be alternating, the rotor will oscillate representing the alternate charging and discharging of the capacitance.

DETERMINATION OF THE CONSTANTS

As the stored energy of the equivalent capacitor is the kinetic energy of the moment of inertia of the rotor

$$\frac{CE_0^2}{2}=\frac{kJ\omega_0^2}{2} \tag{7}$$

in which k is a conversion factor in case different energy units are used on the two sides, and E_0 and ω_0 are corresponding values of no-load voltage in volts and rotational velocity in radians per second. The value of k is unity for the meter-kilogram-second system, and 0.042 for the foot-pound system. Solving equation 7 for C,

$$C=J(\omega_0/E_0)^2 \text{ farads } (J \text{ in square meters}\times\text{kilogram units}) \tag{8a}$$

$$=0.042\ J(\omega_0/E_0)^2 \text{ farads } (J \text{ in square feet}\times\text{pound units}) \tag{8b}$$

As (ω_0/E_0) in 8 is variable by design, the conversion factor from J to C is not a natural conversion factor to be listed in a standard table. Equation 8 also shows how the equivalent capacitance of the machine can be altered.

Capacitance C can be increased by (*a*) increasing the moment of inertia J, as for instance, by adding a flywheel to the shaft; and (*b*) increasing the ω_0/E_0 ratio, for instance, by designing for a weaker field and higher speed operation, with lower volts per radian per second.

The capacitance C can be reduced by (*a*) designing the rotor with reduced moment of inertia; (*b*) increasing the field strength; (*c*) reducing the armature turns, incidentally reducing also the armature reactance L, a beneficial result because X_L subtracts from the X_C of the circuit. This suggests a compensating winding or damping grid to neutralize the armature reaction.

Let us consider now what order of magnitude of C may be expected in conventional d-c motors.

	Machines	
	1 Horsepower	220 Horsepower*
Voltage E_0	125 volts	170 volts
Rated armature current, I	6 amperes	1,260 amperes
Rotor rpm rated	1,140	1,045
Angular velocity, ω_0, radians	118.5	109.5
X_L	4.66 ohms at 25 cycles	17.75 ohms at 25 cycles
	22.4 per cent at 25 cycles	13.3 per cent at 25 cycles
Rotor moment of inertia	0.29 pound×square foot	906 pounds×square feet
$C=0.042\ J\ (\omega_0/E_0)^2$	11,500 microfarads	15,700,000 microfarads
X_C	0.55 ohm at 25 cycles	0.0004 ohm at 25 cycles
	2.64 per cent at 25 cycles	0.3 per cent at 25 cycles
	100 per cent at 0.66 cycle	100 per cent at 0.075 cycle
Resonance frequency	8.6 cycles	3.77 cycles
$R_{effective}$	1.4 ohms	0.01 ohm
	6.7 per cent	7.33 per cent

* Original design a series motor, but modified here to a separately excited motor.

DISCUSSION AND COMMENTS

In both machines the microfarads are most impressive. This makes the capacitive reactance of the armature very low, in fact less than the resistance of the armature,

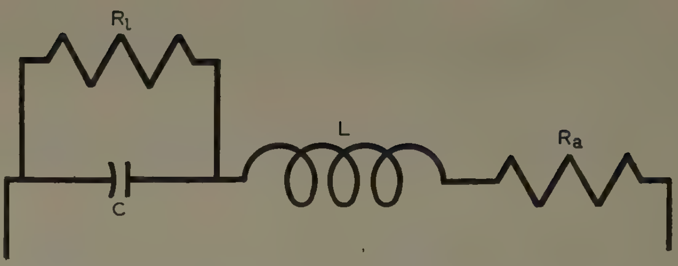

Figure 2. Complete equivalent circuit of separately excited d-c motor

and therefore the capacitance is too large to be of any use for ordinary capacitor applications. Even at as low a frequency as 25 cycles, the capacitive reactance is less than the resistance of the armature. One might think that you cannot have too many microfarads, that the more the microfarads the more valuable the device would be, but that is not true if there is a fixed series R or X_L.

Since capacitive reactance varies inversely as the impressed frequency, these huge capacitances can exhibit desirable X_C values at lower frequencies. The question is how low?

To enable these machines to draw 100 per cent volt-amperes as a capacitor, the 1-horsepower motor has to be operated at 0.66 cycle per second, and the 220-horsepower motor at 1 cycle per 13.2 seconds. If an inventor has been looking for a low-cost high-microfarad capacitor for very-low-frequency applications, here is the desired solution.

Alternatively, to change these machines to 100 per cent net capacitances at 25 cycles (with allowance for the reduction caused by the inductance) the moment of inertia of the 1-horsepower motor has to be divided by 47, and that of the 220-horsepower motor by 380. Obviously this calls for a radically changed construction, providing another opportunity for inventors.

To consider a third alternative, as C varies proportionally to the *square* of (ω_0/E_0), changing the field excitation would seem to be a very effective means of control, but this means raising the field excitation, and most machines already are designed for maximum permissible densities. Considering efficiency, the high armature resistances (6.7 and 7.33 per cent) indicate that the motor-type capacitor is going to be a high-loss capacitor.

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Dielectric Strength of Impregnated Pressboard

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THE IMPULSE dielectric strength of pressboard impregnated with insulating liquids is of interest where such insulation has to withstand high transient impulse voltages. A comparison of the impulse dielectric strength of dry pressboard impregnated with a variety of insulating liquids of differing chemical structure has indicated that, in pressboard, chlorinated compounds of the Askarel type show appreciably lower impulse strength than mineral oil, perfluorinated compounds, or a variety of other liquid compounds. Impulse tests were conducted using the standard $1^1/_2 \times 40$-microsecond wave shape.

An investigation of the difference between the 60-cycle dielectric strength of transformer Askarel and of mineral-oil-impregnated pressboard has shown that the Askarel gives a low impulse ratio of the order of 1.2 compared with 2.3 for the mineral oil. It is pointed out that the dielectric strength with a single cycle of 60-cycle voltage is about the same in both cases as the impulse strength. But, as is shown in Figure 1, the dielectric strength of the mineral-oil-impregnated pressboard decreases rapidly with increasing cycles of alternating current, whereas the transformer Askarel-impregnated pressboard decreases much less with multiple cycles of alternating current, resulting in a relatively high long-time 60-cycle dielectric strength.

This decrease in dielectric strength with increasing number of cycles of alternating current seems to be due to the corona-like discharge in the liquid at the electrode edge. It would be expected to be more severe in the case of the mineral oil due to its lower dielectric constant relative to the pressboard. Thus, the pressboard in mineral oil shows a much greater decline in dielectric strength with multiple cycles of alternating current than is the case with the Askarel whose dielectric constant is more nearly the same as the impregnated pressboard. With multiple cycles of alternating current, the puncture in both cases is usually at the electrode edge.

A study of the polarity effects in impulse testing of the Askarel-impregnated pressboard has shown relatively large differences in the dielectric strength with positive and negative pulses where the electrodes on either side of the pressboard are unsymmetrical. The lowest impulse strengths were observed when a positive rounded-edge electrode was placed opposite a plane electrode, both in contact with the pressboard. All such tests indicate that the breakdown is initiated in the liquid at the edge of the positive electrode, and that the dielectric strength is lower when the stress is high in the liquid at the electrode edge.

The polarity effects are much less pronounced in testing mineral-oil-impregnated pressboard than in the case of the transformer Askarel. By grading the stress at the edge of the positive electrode with a semiconducting coating on the pressboard, it was possible to increase the Askarel-impregnated pressboard dielectric strength. Such grading of the stress, when used at the negative electrode alone, had little effect. The effect of this grading of the stress in impulse testing mineral-oil-impregnated pressboard was much less. This is probably associated with the fact that the impulse puncture with mineral oil is usually located in the central area of the electrode rather than at the edge.

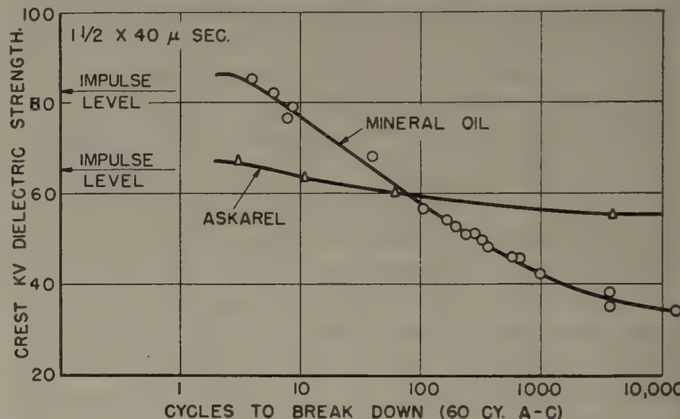

Figure 1. Time to break down impregnated 1/32-inch pressboard

In the case of the Askarel, the impulse puncture is always located at the electrode edge. Sommerman[1] has suggested from observations of the edge corona in such impulse tests that the edge corona in the case of mineral oil acts to grade the stress in a manner similar to the conducting coatings described in the foregoing and is responsible for the higher impulse strength with mineral oil.

This postulated beneficial effect of the corona-like discharge in the case of impulse voltages with mineral oil is to be contrasted with the destructive effect occurring in the case of multiple cycles of alternating voltage.

An analysis of the properties of the wide variety of liquids which were impulse tested in pressboard showed that impulse strength was not correlated with the dielectric constant of the liquid nor its vapor pressure. But in the case of chlorinated liquids, all of which gave low impulse strength, the impulse strength seemed to be higher when the viscosity was higher, as in the case of capacitor Askarel pentachlordiphenyl.

Digest of paper 52-228, "Impulse Strength Characteristics of Liquid-Impregnated Pressboard," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Variation in the Dielectric Breakdown of Paper

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THIS REPORT covers results of tests to determine the dielectric breakdown characteristics of 3-mil paper sheets, each treated, measured, and tested according to standard paper making and standard electrical procedures. The unique feature here is the successful attempt to hold the density of the paper constant and vary the air resistance through wide limits, and thus give a relation between dielectric breakdown and air resistance.

Starting with unbeaten pulp, a series of curves, Figure 1, are obtained between density and hydraulic pressure at the press for each of four beating times. Inspection shows that a constant density line of 0.760 gram per cubic centimeter crosses all pressure lines except that for zero beating. The value for it is readily obtained by minor extrapolation.

Fifty sheets at each of the four beating times and hydraulic pressure indicated by Figure 1 were made seven at a time, each sheet carefully calipered in four or five different spots by a micrometer, weighed in an analytic balance, and the air resistance of each sheet determined by a standard densometer. A given lot is treated at 105 degrees centigrade at 2 millimeters of mercury for 24 hours impregnated with moisture-free WEMCO *50* transformer oil, tested at once for dielectric breakdown under the same kind of oil. The oil is filtered after each run.

The average of the breakdowns for each set of sheets together with the average deviation is as follows, while the plot of these values is given in Figure 2:

Set	Average Thickness	Average Density, Grams/Cubic Centimeter	Air Resistance, Seconds	Breakdown Strength Volts/Mil 60 Cycles	Mean Deviation
1	3.00	0.765	1384.0	2,165	99
2	2.96	0.809	364.1	2,075	105
3	3.15	0.760	168.7	1,975	114
4	3.09	0.772	49.8	1,717	151

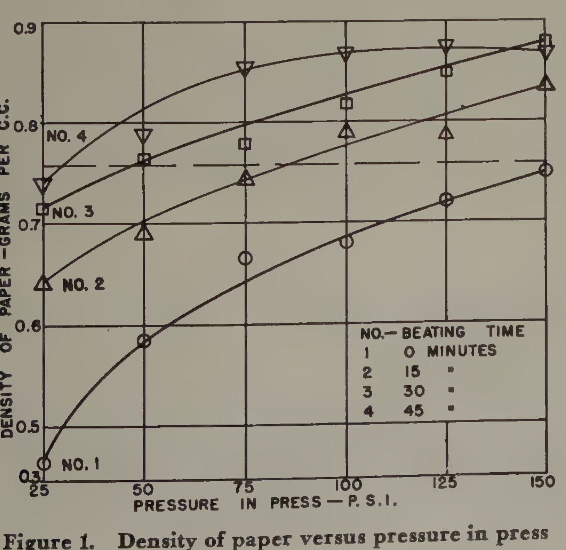

Figure 1. Density of paper versus pressure in press

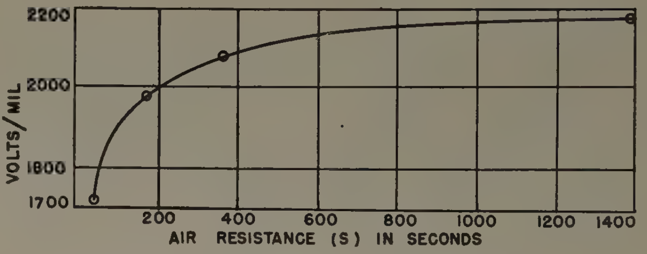

Figure 2. Breakdown versus air resistance

Another feature of the investigation is the special electrode[1] used which practically eliminates edge effect. Its 1/2-inch radius central part is flat. The outer part of 1-inch radius is curved according to an equation derived on the basis that the transverse breakdown strength should be at least 50 times the strength parallel to the plane of the paper sheet. The lower electrode is flat. A paper guard is sanded down to fit the curved portion of the upper electrode. The efficacy of this device is attested by the fact that of 591 breakdown observations made in this investigation, only two came outside the flat central portion of the upper electrode thus giving the true dielectric strength.

Air resistance determined by a standard densometer is the best measure of the bonding of the fibers in paper. Prolonged beating results in breaking up of the paper fibers and gives a more or less gelatinous mass which may result in an impervious paper. Within limits, increased pressure in the press will give about the same result as beating. The pressure applied is very important as it affects density and strength. If one stock is beaten more than another, a constant density can be obtained by varying the pressure at the press as the authors have done.

Electrolytic impurities such as chlorides, hydroxides, sulfates, and sulfides resulting from bleaching and cooking, also resinates, acid salts, lignin, and ash must be eliminated in paper for electrical insulation. With paper for capacitors prolonged beating is necessary, whereas in low-density porous cable papers the procedure is quite different.

The curve, Figure 2, shows that prolonged beating or high pressure does not produce much gain in dielectric strength and also that the strength falls off very sharply at low values of either hydraulic pressure or beating.

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This study was made at the University of Maine with which both authors were associated at the time.

Relation of Transformer Design to Fire Protection

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THE DESIRE FOR improvement in the fire risk of oil-filled transformers promoted the introduction of the Askarel-insulated type. These have well-demonstrated characteristics of noninflammability and no production of explosive breakdown materials which can contribute to secondary explosions. Extensive internal faults, however, can produce disruptive pressures and severe mechanical effects.

The introduction of the open and the sealed dry-type transformers removed all liquids and reduced the amount of inflammable material in the solid insulations. Extensive tests now have been made on the various component insulating materials yet remaining, to determine their action under conditions of transformer failure.

Tests in accordance with American Society for Testing Materials (ASTM) Method *D-635-41T*[1] show that representative samples of insulation classes *A*, *B*, and *H* are all classed as "self-extinguishing" for the 1/4-inch thick samples specified. It undoubtedly is true that below a certain thickness some of the samples, if not all, will cease to be self-extinguishing.

Tests in accordance with ASTM Method *D-229-49*,[2] show a marked difference in flammability in representative materials of each class. See Table I.

Insulation samples were placed in a vented container with the correct ratios of weights of insulation and volume of container to simulate a sealed dry-type transformer. With the container heated strongly gases from all insulation samples, whether class *A*, *B*, or *H*, will burn continuously at the vent, except one special flame resisting class *B* sample which burns only initially.

Insulation samples are decomposed in a closed system in a nitrogen atmosphere and the volumes of gases evolved measured and analyzed. See Table II.

From these data, we might conclude that turn insulation involved in faults continuing to complete disintegration in a sealed dry-type unit may be classified as shown in the last four lines of Table II.

In these pressure computations, the external fault was assumed to be of long duration so that all turn insulation was disintegrated, and the localized internal fault was of cycles or seconds duration involving only 10 per cent of the turn insulation.

It thus is of particular interest in open dry-type transformer applications that insulations of the order of 1/4-inch thick are self-extinguishing irrespective of class after subjection to moderate flame. Ignition rate tests show class *H* insulations much superior, with some class *B* insulations quite outstanding. Also, class *B* may be better or poorer than class *A* depending upon materials used. Most normal insulations irrespective of class give off inflammable vapors when heated strongly, although a special class *B* insulation, not now in general use, shows outstanding noninflammable characteristics. Class *B* may evolve a greater or a less total volume of gas than class *H*, and also class *B* may have a considerable percentage of noninflammable gas (CO_2) and, as a result, actually have less inflammable material.

In the case of sealed dry-type transformers, the class *B* and *H* insulations produce only about 10 to 30 per cent as much toxic gas as class *A*. Under external fault conditions and assuming a duration sufficient to decompose all turn insulation, it appears that, except for one sample tested, any of the classes of insulation tested conceivably may produce pressures that will rupture normal transformer tanks. However, under localized internal fault conditions involving of the order of 10 per cent of the winding, the transformer tank probably will withstand the pressures produced. It appears that class *B* compares favorably with class *H* as regards flammability and pressures produced in sealed transformers.

Table I. Flammability

Insulation Class	Seconds to Ignite	Number of Samples That Continued to Burn With Power Off—in Per Cent
A	47–118	100
B (3 types)	32–146; some failed to ignite	56
B (4th type)	Failed to ignite	0
H	Failed to ignite	0

Table II. Decomposition Products

	Insulation Class			
	A	B*	B*	H
% Total gas evolved referred to class A	100	77.5	25.0	56
Analysis of gases evolved				
% Unsaturated hydrocarbons	7	9.3	0	25.2
% Saturated hydrocarbons	0	11.5	40	51.6
% Hydrogen	53	3.3	34	18.0
% Carbon monoxide	40	15.8	13	5.2
% Carbon dioxide	0	60	13	0
Liquids evolved by weight				
% Water	5.5	7.9	0	0
% Nonvolatile liquid	5.5	5.5	7.7	0
% Combustible gas	100	31	22	56
% Toxic gas	100	30	8	7
Pound gauge pressure—external fault	60	47	19	35
Pound gauge pressure—localized internal fault	12	11	6	7

* Two different types.

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The Electronic Discrete Variable Computer

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The EDVAC is a large-scale digital computer utilizing an unconventional language and logical structure to solve complex problems. A discussion of these elements is followed by a description of the units that mechanize these characteristics.

THE Electronic Discrete Variable Computer (EDVAC)*[1,2] is a radical departure from its predecessor, the Electronic Numerical Integrator and Computer (ENIAC).**[3,4] Utilizing a mercury-acoustic high-speed memory, the binary number system, and serial presentation of data, the EDVAC is designed for problems that the ENIAC, with its relatively small memory capacity, is not capable of handling.

LOGICAL STRUCTURE

THE EDVAC stores in its mercury memory the numbers to be computed, the results of the computations, and the orders necessary to carry out arithmetic and nonarithmetic operations. The machine, once operation is initiated, can control the sequence of the computations automatically and, when the memory contents are exhausted, it can call upon an input-output system to supply additional orders and numbers or halt the calculations. A "four address" method of coding gives the machine this flexibility. Basically, the EDVAC is only capable of addition, subtraction, multiplication, and division. Outwardly, this might not seem to be a machine capable of solving complex mathematical problems. However, there is a large class of problems that can be solved by numerical methods that require only these simple arithmetic operations. The number of calculations for one solution is great and it would be impractical to use hand computational methods. It is the high speed of electronic computers which permits this technique to be used effectively. This discrete method of solution requires the reduction of the problem to a program of arithmetic operations. With only the basic computing orders present, this scheme would be possible though tedious. Therefore, in addition to the arithmetic orders, there are included other nonarithmetic orders and controls all designed to simplify the work of the programmer and allow the machine to compute with a minimum of attention from the mathematician.

LANGUAGE

THE BINARY number representation is used throughout the EDVAC. Since the base of this system is 2, only two characters *0* and *1* are needed to designate the value of any one binary digit.† This characteristic of the language permits the circuits of the machine to be of a reliable "on-off" nature. The use of the base 2 simplifies the design of arithmetic circuits, particularly those for division.

A sequence of binary characters called a "word" can represent either a number with its sign, or an order, which is an instruction to the machine. A word within the strictly electronic part of the EDVAC consists of a sequence of 44 binary digits followed by 4 blanks. The two binary characters are represented by a pulse, normally interpreted as signifying *1*, and the absence of a pulse, normally interpreted as signifying *0*. A word comprises 48 pulse positions spaced 1.0 microsecond apart. Timing pulses from the Timer allow a pulse position with no pulse to be identified; the EDVAC is a synchronous computer. A complete word requires 48 microseconds to pass a given point in the machine.

When a word represents a number, see Figure 1, the first binary character that appears in time represents the sign (the presence of a pulse denoted "minus"), the next is the least significant digit, and the last is the most significant. Each number has 43 binary digits and a sign. The characters are arranged so that increasing time corresponds to the direction right to left in written notation. Usually it is convenient to consider the "point" as lying at the extreme left, as the numbers are fractional, in which case the numbers in the machine lie in the interval $-(1-2^{-43})\leq X\leq +(1-2^{-43})$ and vary by increments of 2^{-43}. Multiplication and division operations interpret the numbers as if this were the case. However, with appropriate programming, the machine can disregard this limitation as to the size of the number and compute as if the "point" were at the right of the least significant digit and the range of numbers were $-(2^{43}-1)\leq X\leq +(2^{43}-1)$ in increments of $2^0(=1)$. Regardless of what interpretation is taken of the size of the number, an evaluation must be made of the size of the numbers the EDVAC can compute. To do this, it is best to compare the binary number system with a number system whose base is more familiar, that is one with base 10. The following relation gives the number n of digits required to express a given integer x in any given base β.

$$n=1+[\log_\beta x] \text{ where } [\log_\beta x] \text{ denotes the largest integer in } \log_\beta x \quad (1)$$

Taking $x=2^{43}-1\approx 2^{43}$ as the maximum number

* The EDVAC was designed and constructed by the University of Pennsylvania, Moore School of Electrical Engineering, for the Ordinance Department, Department of the Army, under Contract Number W36-034-ORD-7593.

** The ENIAC was designed and constructed by the University of Pennsylvania, Moore School of Electrical Engineering, for the Ordinance Department, Department of the Army, under Contract Number W-670-ORD-4926.

† Binary digits are indicated as *0* and *1* to differentiate them from regular numerals.

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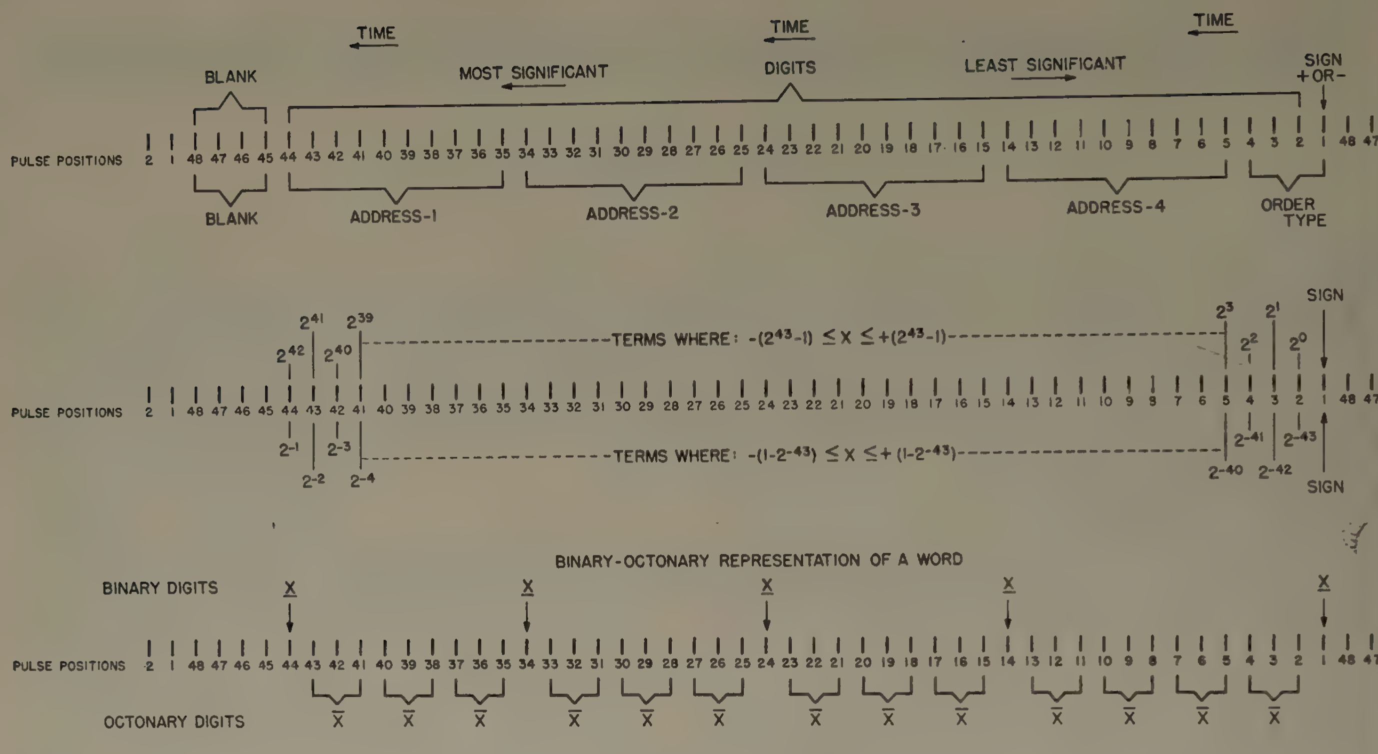


Figure 1. EDVAC word structure

that can be utilized by the machine, n then becomes:

$$n=1+[\log_{10} 2^{43}]=1+[43 \log_{10} 2]=1+[12.943]$$
$$n=1+12=13 \text{ digits}$$

Interpreting this answer, n=13 indicates that $2^{43}-1$ can be evaluated by 13 decimal digits; or, the 43 base 2 digits of an EDVAC number are equivalent to at least 13 digits in the base 10.

The expression

$$x=\sum_{i=0}^{p-1} a_i\beta^i \text{ where } \beta\geq 2 \text{ and } 0\leq a_i\leq\beta-1 \tag{2}$$

represents the value of a p-digit integral number, expressed in any integral base β. This polynomial when expanded and written with the least significant digits on the right, to correspond to the appearance of digits in the EDVAC, appears as:

$$x=a_{p-1}\beta^{p-1}+a_{p-2}\beta^{p-2}+\ldots\ldots\ldots a_2\beta^2+a_1\beta^1+a_0\beta^0 \tag{3}$$

Let p=43, the maximum number of digits the EDVAC can handle, and $\beta=2$.

$$x=a_{42}2^{42}+a_{41}2^{41}+\ldots+a_2 2^2+a_1 2^1+a_0 2^0$$

Since a_i can be only *1* or *0*, the valuation of this polynomial is simply the summation of terms with a coefficient of *1* and the omission of those terms with a *0* coefficient. If the machine assigns a specific pulse position in a number word for each term of the polynomial, all the machine need know is the coefficient of each term. Therefore a number is represented by a series of *1*'s and *0*'s, that is by pulse or no pulse respectively, the machine is able to determine what term is represented by comparison of the pulse position with a reference pulse from the Timer. If, as an example, the following code is seen, and its timing established:

Binary Number:	*1*	*0*	*1*	*1*	*0*	*0*	*1*
It can be evaluated as:	$1(2^6)$	$+0(2^5)$	$+1(2^4)$	$+1(2^3)$	$+0(2^2)$	$+0(2^1)$	$+1(2^0)$
which is the decimal number:	64	+ 0	+ 16	+ 8	+ 0	+ 0	+ 1 = 89

Since the EDVAC usually is considered to compute with fractional numbers lying in the range $-(1-2^{-43})\leq X\leq +(1-2^{-43})$, any number considered in this range must be expressed by the polynomial

$$x=\sum_{i=1}^{p} a_i\beta^{-i} \text{ where } 0\leq a_i\leq\beta-1 \text{ and } \beta\geq 2$$

If

$\beta=2$, p=43, and $a_i=$*0* or *1*

$$x=a_1 2^{-1}+a_2 2^{-2}+a_3 2^{-3}+\ldots+a_{42}2^{-42}+a_{43}2^{-43}$$
$$=\frac{a^1}{2^1}+\frac{a_2}{2^2}+\frac{a_3}{2^3}+\ldots+\frac{a_{42}}{2^{42}}+\frac{a_{43}}{2^{43}}$$
$$=a_1\left(\frac{1}{2}\right)+a_2\left(\frac{1}{4}\right)+a_3\left(\frac{1}{8}\right)+\ldots$$

The same method of evaluation holds as described previously for integers, with the least significant digits appearing earliest in time, and at the right in written notation.

It is to be noted that for purposes of convenience, binary numbers are sometimes written as their octonary* equivalent or in combinations of both systems. If one takes three binary digits and considers them to be coefficients of the terms 2^2, 2^1, and 2^0, respectively, one gets a range of octonary numbers from **0** through **7**. Thus, three binary digits can be represented by one octonary

* Octonary digits are indicated as **1** to differentiate them from binary digits *1* and ordinary numerals 1.

digit. The foregoing example of binary coding of an integer can be written in this way:

$$\begin{array}{ccccccccccccc} 1 & & 0 & 1 & 1 & & 0 & 0 & 1 & = & 1\ 3\ 1 & = & 89 \\ & & 2^2 & 2^1 & 2^0 & & 2^2 & 2^1 & 2^0 & & & & \\ 1 & & & 3 & & & & 1 & & & & & \end{array}$$

An entire word, number, or order, is broken into binary-octonary groups as shown in Figure 1.

The 44 binary characters in a word can also represent an order, that is, a set of instructions to the machine giving the operation to be performed, the location in the high-speed memory of the pair of numbers to be computed, where in the memory to place the answer, and the location of the next instruction. This method of coding is known as a Four Address Code. Each of the 1,024 locations or registers in the high-speed memory has a unique binary coded "Address" consisting of 10 binary digits ($2^{10}=1,024$). Figure 1 shows the four addresses preceded in time by four binary characters which are decoded to determine the Order Type, or operation the machine is to perform. There are $2^4=16$ operations possible, but only 11 are used. It is to be noted that for reasons of programming convenience, the four addresses appear in the reverse order from that in which they must be used. The sequence of the addresses, A_1, A_2, A_3, A_4 from left to right is the order in which they are read by decoding circuits. Address One, which designates the location of the first of the two numbers to be computed (the addend, minuend, multiplier, or dividend for addition, subtraction, multiplication, or division, respectively) is coded by the last ten characters. Address Two preceded it in time and represents the location of augend, subtrahend, multiplicand, or divisor. The ten pulse positions which precede Address Two contain the code for Address Three, designating the location in the memory reserved for the answer of the computation. The remaining ten binary digits allow the selection of a memory position containing the next order for the machine to decode and perform. It is this feature of allowing orders to be stored anywhere in the memory which gives the Four Address Code its great advantage of flexibility and ease of programming. Orders other than those of a strictly arithmetic nature are within the scope of the machine. They utilize Addresses One, Two, and Three for other purposes than those described, but in all cases save one, Address Four denotes the location of the next order the machine will perform.

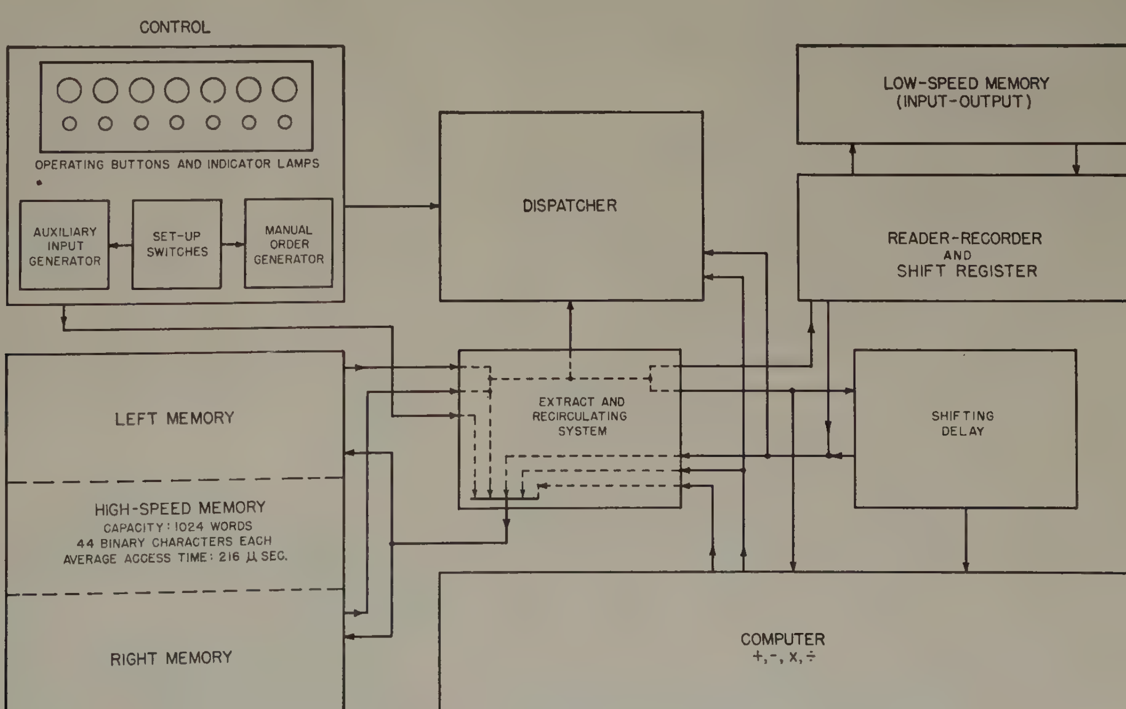
MAJOR UNITS

THE EDVAC is composed of eight functional units, each unique in its basic operation, but dependent upon all the other units for its sources of control signals and information, see Figure 2.

1. *Control.* The Control Unit is the supervisory mechanism containing the principal manual operating controls, such as those necessary to turn the power on or off, start or stop the calculations, select various optional modes of operation, and set up the initial order in a chain of instructions. It contains monitoring apparatus, such as an oscilloscope for viewing the contents of any memory position throughout the machine, a neon light register for recording static and transient data for as long a period as desired, and visual and audible presentation of normal and abnormal cessation of computing.

2. *High-Speed Memory.* The High-Speed Memory stores in mercury-acoustic delay lines 1,024 words of information. Each word contains 48 pulse positions, 4 of which are blank to provide switching time, and the remaining 44 contain binary characters representing either a number

Figure 2. EDVAC block diagram



NOTES: 1. COMPONENTS OMITTED FOR SIMPLICITY: (a) TIMER, (b) POWER SUPPLY, (c) NEON LIGHT REGISTER, (d) OSCILLOSCOPE, (e) MODE OF OPERATION SWITCH, (f) EXCEED CAPACITY OPTION SWITCHES, (g) ADDRESS A GENERATOR, (h) ADDRESS B GENERATOR.
2. THE INTERCONNECTIONS ALL CARRY DATA; NO CONTROL CONNECTIONS ARE SHOWN.

or an order. There are 128 delay lines, each with the capacity of 8 words, mounted in two temperature-controlled cabinets with their amplifiers and control circuits. The controls are designed so that a word transmitted from the memory is not deleted, that is, the word is copied. When a word is delivered to the memory, the former contents are erased and the new word is memorized.

3. *Reader Recorder and Low-Speed Memory.* The Reader Recorder utilizes a shift register to transfer asynchronous information between the low-speed memory, also used as an input and output, and the synchronous high-speed memory.

The low-speed memory can be any nonvolatile medium, that is, any medium capable of long-time storage of information with power removed from the machine. Examples of such a medium are magnetized wire, originally intended for use with the EDVAC, magnetized tape, punched paper tape, punched cards, and photographic film.

The EDVAC now uses punched-paper teletype tape as an interim input-output system. High reading speeds are accomplished by means of photoelectric scanning. Eventually, magnetic tapes and drums will be added to the EDVAC for auxiliary storage. The Reader Recorder design is such that these new equipments can be added with a minimum of logical changes.

4. *Dispatcher.* The Dispatcher, once EDVAC operations are initiated, automatically controls the entire machine. It is a device for receiving, memorizing, and decoding the 44 binary characters of an order word and it transmits in proper sequence the resulting instructions to the various units of the machine.

5. *Shifting Delay.* The Shifting Delay is used with the Dispatcher to perform a variable shifting operation for a word modification order called Extract. This order is capable of interchanging sections of orders or numbers with others and is essential in the conversion between binary and coded decimal numbers.

6. *Extract and Recirculating System.* The Extract and Recirculating System is a system of information busses and switching circuits through which all numbers or orders transmitted between the high-speed memory and any other units must pass. The actual word modification operation, Extract order, is performed in this unit.

7. *Computer.* The Computer performs the rational operations of addition, subtraction, multiplication, and division under the control of the Dispatcher. Two versions of multiplication and division are available, one pair of orders performs the operations with round-off and the other preserves all of the data in the result. The Computer also generates the data needed in the Compare operation which modifies the sequence of a program of orders if one of two numbers is greater than the other. The Computer's calculations are done in duplicate simultaneously, any disagreement in results stops the machine and gives the appropriate diagnostic signals to the Control.

8. *Timer.*[5] The Timer contains the master pulse generator which emits clock pulses every microsecond and the timing pulse matrix with 48 outputs, each of which emits a pulse once every 48 microseconds. The outputs are arranged so that a pulse first appears at output P_1, 1 microsecond later a pulse appears at output P_2, and so on up to P_{48}, after which a pulse appears again at P_1. The timing pulses and clock pulses are used to maintain synchronism throughout the machine and to determine by comparison the contents of a pulse position.

PRESENT STATUS

The EDVAC was delivered to the Ordinance Department in the fall of 1949. The machine was installed at the Ballistic Research Laboratory at Aberdeen Proving Grounds, Md. There, under the direction of R. L. Snyder, the EDVAC has undergone a program of modification of some of the electronic circuits and a change in the media and logic of the input-output system and auxiliary memory.

At the beginning of March 1952, the EDVAC was considered to be a working machine. It was then operated on a 24-hour-a-day basis, and during this period, was available to the mathematicians 60 to 70 per cent of the time. Runs up to 10 hours without detectable errors have been obtained on the EDVAC.

The EDVAC is now being used with a photoelectrically scanned teletype tape for input, and normal mechanical punches for teletype tape as output. Teletype printers transcribe from the punched tape to the printed page. By the end of 1952, additional equipment will be installed for input-output. Card-handling devices will be installed for both input and output. In addition, a magnetic drum will be used for auxiliary storage. Before the end of 1952, the installation of a high-speed printer will increase the speed of the EDVAC to read out printed results.

CONCLUSION

The ENIAC was the first large-scale electronic digital computing machine and the EDVAC is its successor. As such the EDVAC embodies major advances over its predecessor in magnitude of problems which can be handled, storage capacity, programming, and decrease in physical size. The EDVAC is one of numerous current developments in the large-scale electronic computing field which, taken as a whole, will form the base for a new and rapidly expanding area of electrical engineering. The effect of applications of new computers in technology, industry, and business may be far-reaching in expanding the scope of the problems or the volume of data which can be handled in reasonable time, in extensive labor saving, and in the extension of our knowledge in basic sciences such as mathematics.

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Applying Carrier Coupling to Typical Installations

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IN THE APPLICATION of power-line carrier equipment, the development of quantitative information on the transmission path has been slow. The first widespread use of carrier was for protective relaying where the configuration of the transmission path was simple. As a result of hundreds of successful installations of the carrier relaying equipment on typical transmission lines, certain assumptions on which the application of tuning equipment and traps were based were adopted throughout the carrier industry.

As the application of carrier was extended to more complex transmission systems, many troubles were experienced in field installations which could not be explained in the light of existing application practice.

Because of the difficulties experienced in application of carrier, a continuing program of investigation has been carried out to get better data on transmission-line attenuation and noise levels at carrier frequencies. This article is intended to discuss other factors which are important in establishing an adequate transmission path. It will be presented in two parts. Part I discusses the requirements which are placed on this transmission path by typical carrier services and proposes methods of determining if a given channel is suitable for a particular service. Part II will discuss methods of treating a channel to make it suitable for a particular service.

Ideally, a carrier transmission channel should introduce only noise and attenuation to a carrier signal. Actually in most systems an appreciable amount of bandwidth restriction and signal distortion is introduced by the channel.

For voice communication over the average power-line carrier channel the important consideration is intelligibility rather than high quality of reproduction. An intelligibility of greater than 95 per cent can be obtained when an audio bandwidth of 250–2,150 cycles is reproduced. For other services such as protective relaying, telemetering, load control, and supervisory control, a channel of considerably reduced bandwidth is permissible.

Listening tests conducted both in the laboratory and on several field installations have led us to the conclusion that distortion of the order of 10–12 per cent is quite acceptable for power-line carrier channels for voice communications only. However, where a channel is being used for more than one function simultaneously, as with voice plus tones, the distortion introduced by both carrier equipment and transmission channel must be not greater than 1–4 per cent. For a system employing only multiple tones on a carrier audio channel, distortion of the order of 10–12 per cent is again usually satisfactory.

A typical single-frequency carrier channel is shown to be the equivalent of two series-tuned circuits in cascade between transmitter output terminals and receiver input terminals. For satisfactory operation of the channel, the bandwidth and the phase characteristic must be such that we get sufficient audio spectrum and low enough distortion to meet the requirements of the service involved.

The bandwidth and phase characteristic can be predicted if we know the Q of the circuits. However, this can be determined readily for each circuit by dividing the reactance of the coupling capacitor by the total series resistance of the circuit.

With the value of Q thus determined, by inspection of universal resonance curves we can predict with reasonable accuracy the lowest frequency for which a system can be used without deteriorating performance below the standards recommended in the foregoing. The requirements are considerably different for different types of modulation. Each of the three types of modulation commonly used is considered separately. Formulas are derived which, for a single-frequency system, determine the lowest frequency which can be used to provide a given service for frequency modulation, amplitude modulation, and single sideband modulation.

The discussion and derivations made were based on the following assumptions: 1. That shunt devices such as power transformers have high impedance as compared to transmission-line impedance; 2. That all transmission lines at a point of coupling are long enough to have an input impedance which is resistive and equal to the characteristic impedance of the line; and 3. That the tuning equipment completes a single series-resonant circuit. In many field applications, these assumptions are valid and the formulas apply directly.

For short lines or lines having short taps along their length, it is quite possible to have standing waves on the power lines which may make the line look either inductive or capacitive at the point of coupling. Shunt elements such as power transformers on the system may make the load impedance at the point of coupling vary over wide limits. If the value of the complex input impedance is known, it is possible by derivations similar to those used herein to predict the lowest frequency which might be used. Usually, to determine the value of this complex impedance it is necessary to measure the actual transmission channel.

When such measurements on transmission-line attenuation are available, a very simple graphical method can be used to determine a suitable operating frequency for the desired service. This method is the one described in the article.

Digest of paper 52-220, "The Application of Power-Line Carrier-Coupling Equipment to Typical Field Installations—Part I," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Automatic Phase Angle and Voltage Control

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IN THE MARCUS HOOK AREA, a few miles south of Chester, Pa., the Philadelphia Electric Company supplies a large concentration of industrial load, requiring a high degree of service continuity. Heretofore this load has been supplied directly from the Chester Generating Stations by means of 13.8-kv 3-phase underground cable lines. To provide reliable service, many of the customers in this area have been provided with dual service lines, and in most instances the two lines have been operated in parallel.

Foreseeing a growing demand for power, studies were made to determine the best method of providing increased capacity. It was decided to construct a new step-down substation at Marcus Hook supplied from the 69-kv bulk power transmission system, and to operate certain of the 13.8-kv outgoing lines of this new substation in parallel with the 13.8-kv lines from the Chester Station to provide the required degree of reliability.

However, this introduced a problem of circulating currents. Figure 1 shows the closed loops through the 13.8-kv cables from Chester Station to Marcus Hook Substation by way of the customers' substations, returning to Chester Station over the 69-kv system. Sustained circulating currents flowing around these loops could overheat and damage the cables.

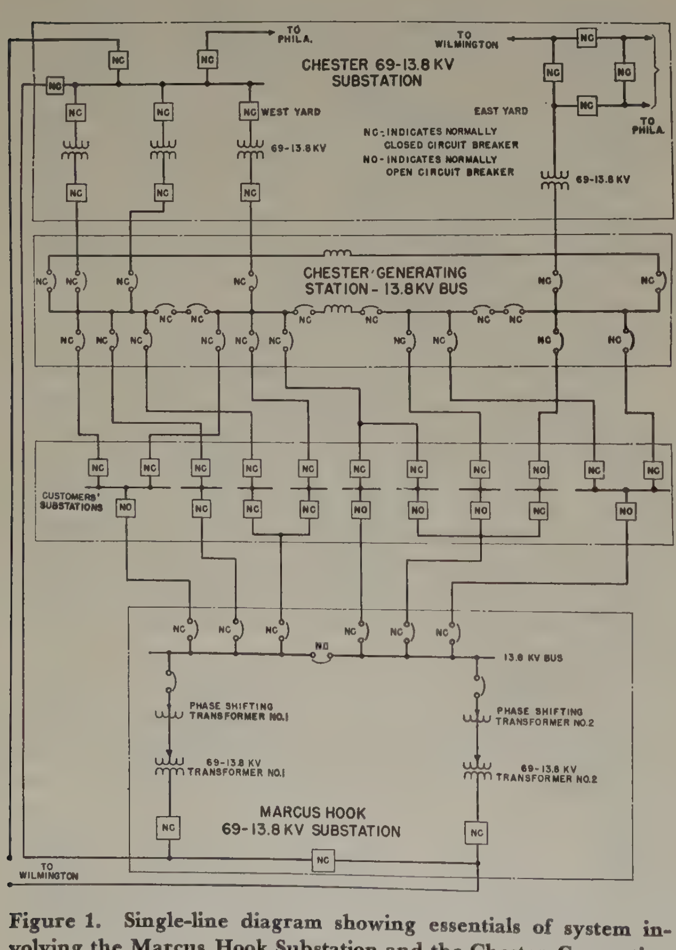

Figure 1. Single-line diagram showing essentials of system involving the Marcus Hook Substation and the Chester Generating Station

Investigations were made of the nature and magnitude of loads to be carried by the cables, and the range of variation of voltage and phase angle in the 69-kv system under various system connections. Different transmission system connections, generation, and load conditions affect the loading of the 69- to 13.8-kv transformers at Chester Station and the 69-kv lines from Chester to Wilmington. They all affect the amount of voltage and phase-angle correction required. The investigation indicated that the problem of circulating currents could be minimized if the voltage and phase angle of the Marcus Hook Substation bus could be varied over a reasonable range. Therefore, it was decided to use tap changing under load step-down transformers and phase-angle regulating transformers at Marcus Hook so that the Chester and Marcus Hook 13.8-kv bus voltages could be maintained equal in magnitude and phase angle.

It was concluded that the two 13.8-kv bus voltages could best be maintained equal in magnitude and phase angle by means of automatic equipment. With the regulating done at Marcus Hook, it required that the Chester 13.8 kv be taken to Marcus Hook for comparison with the Marcus Hook 13.8 kv. While the distance between Chester and Marcus Hook is only a few miles, the cost of installing a cable could not be justified and the loop resistance of a pair of wires which could be leased from the Telephone Company was in excess of 1,500 ohms. With this high value of line wire resistance it was apparent that the burden of any regulating devices which received the Chester voltage over a pair of telephone wires would have to be made extremely low. As no available regulating equipment was suitable, electronic phase angle difference and voltage difference regulators were developed.

To take care automatically of all of the regulating conditions which can occur due to system conditions, two electronic phase-angle difference regulators, two electronic voltage-difference regulators, one solenoid-type watt balance regulator, and one solenoid-type var balance regulator were installed at Marcus Hook. A single pair of leased telephone wires supply the Chester 13.8-kv bus voltage to all the electronic regulating equipment.

The installation has been in operation since early 1950, proving the practicability of comparing the magnitude and phase angle differences of two voltages remote from each other by the use of electronic equipment.

Digest of paper 52-22, "Automatic Phase Angle and Voltage Control of Unattended Marcus Hook Substation," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Commutation's Effect on Magnetic Amplifier Stability

MASAO SAKAMOTO

A THEORY ASSOCIATING the commutation phenomena[1,2] with the unstable behavior of magnetic amplifiers with slightly less than 100-per-cent positive feedback is presented here.[3] Although the study has been based upon the well-known self-saturating doubler circuit, the results of the study may be expected to apply equally well to other types of feedback magnetic amplifiers where commutation exists.

Instability or triggering in feedback magnetic amplifiers with apparently less than 100-per-cent positive feedback has been observed by investigators in the field of magnetic amplifiers. In particular, this triggering effect is manifested when core materials with highly rectangular hysteresis loops are used.

A study of experimental magnetic amplifiers with rectangular loop core materials indicates that the range of triggering is confined to relatively low outputs of the amplifier, with the lower trigger point occurring near minimum output. This is illustrated in Figure 1. This behavior of the amplifier is in some respects similar to the binary stable magnetic amplifier which has been treated in detail by Fitzgerald[3] and others. However, binary stable operation requires more than 100-per-cent positive feedback and is usually characterized by a large range of discontinuity.

In the feedback magnetic amplifier, the feedback ampere-turns are proportional to the average value of the output current and hence may be represented graphically by a straight line as shown in Figure 2. If the simple output characteristic of the magnetic amplifier without feedback is drawn on the same graph as illustrated, the horizontal distance between the feedback line and the simple output characteristic represents the control ampere-turns required.

Triggering is explained on the basis of the existence of a nonlinear feedback line as shown dotted in Figure 2. As the control magnetomotive force is increased progressively as shown at *A*, *B* and *C*, stable operation is to be expected. However, a very slight increase in the control magnetomotive force at *C* would cause the amplifier to seek equilibrium at *D*. Decreasing the control magnetomotive force at *D* would cause the output to drop slightly as shown at *E*. A slight decrease in the control magnetomotive force shown at *E* would cause the amplifier to seek equilibrium at *B*. Although the interval of discontinuity may be small, this results in a bistable characteristic.

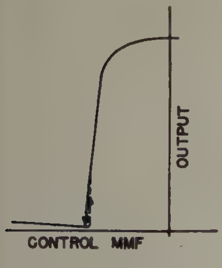
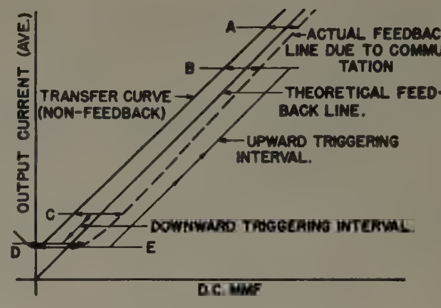


Figure 1. Instability in magnetic amplifiers with slightly less than 100 per cent feedback

The existence of such a nonlinear feedback line has been confirmed experimentally. In securing experimental data a high-resistance d-c bridge source was used to favor commutation. The half-wave average value of the currents flowing in the power windings of the self-saturating magnetic amplifier exceeds that of the load current. This phenomenon is directly associated with commutation and is a consequence of the even harmonic magnetomotive force requirements of the magnetic amplifier. The inward curvature of the actual nonlinear feedback line at minimum output is a characteristic of magnetic amplifiers using rectangular hysteresis loop materials with relatively large coercive forces. Commutation also exists for magnetic amplifiers using rounded knee materials with low coercive forces. In the latter case, however, the positive feedback effect of commutation increases rapidly as minimum output of the amplifier is approached due to the relatively small core loss components of current involved. This prevents the actual nonlinear feedback line from approaching the theoretical feedback line at minimum output leading to singularly stable operation. When a low-resistance d-c source was used, a simultaneous reduction in commutation and interval of triggering was noted.

Figure 2. Postulated nonlinear feedback line leading to instability



On the basis of the existence of the nonlinear feedback line due to commutation, it is possible to explain:

1. The confining of the triggering interval at small outputs of the magnetic amplifier.
2. The larger upward triggering interval and the substantially smaller downward triggering interval.
3. The small but distinct drop in output just prior to triggering in the upward direction.
4. The elimination of triggering at a critical supply voltage.

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2. Analytical Determination of Characteristics of Magnetic Amplifiers With Feedback, **D. W. VerPlanck, L. A. Finzi, D. C. Beaumariage.** AIEE *Transactions*, volume 68, part I, pages 565–70.

3. Feedback in Magnetic Amplifiers, **A. S. Fitzgerald.** *Journal of the Franklin Institute*, (Philadelphia, Pa.), volume 47, March and May, 1949, pages 223–43, 457–71.

Digest of paper 52-233, "The Effect of Commutation on the Stability of Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Not scheduled for publication in AIEE *Transactions*.

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High-Speed Multiple-Reclosing Oil Circuit Breaker

B. P. BAKER
FELLOW AIEE

G. B. CUSHING
MEMBER AIEE

THE RAPID EXPANSION of electric power requirements in the Tennessee Valley area has created a demand for circuit breakers which has greatly exceeded previous records both for size and number of units involved. Present requirements call for over 100 3-pole units, all rated at 10,000,000 kva 161 kv, and applicable on high-speed, single-, double-, and triple-reclosing duty at rating factors of 84, 64, and 51 per cent, respectively.

Figure 1 shows one of the first of these circuit breakers to be installed. While the new and difficult requirements were met without departing from the time-tested concept of the conventional dead-tank oil circuit breaker, many simplifications and improvements were incorporated to obtain better performance in smaller space.

The advantages of shipping and installing a completely factory-assembled-and-adjusted unit, long recognized in lower voltage frame-mounted circuit breakers, have been attained now for larger circuit breakers by permanently mounting the three poles on a pair of H beams. Only the bushings and interrupters are removed for shipping clearance, thus making a tremendous saving in installation time and expense.

Due to the high rate of arc energy release when interrupting large values of current, the interrupters and bushings have been strengthened and two shock-absorbing surge tanks have been located at the bottom of each pole unit. These tanks, consisting of segment-shaped inverted steel pockets, trap a volume of air when the circuit breaker is filled with oil. During interruption the downward component of the shock wave set up by the expanding gas from the interrupter is absorbed by oil flow into the surge tanks so that the ground shock, circuit-breaker jump, and external demonstration are reduced to a minimum.

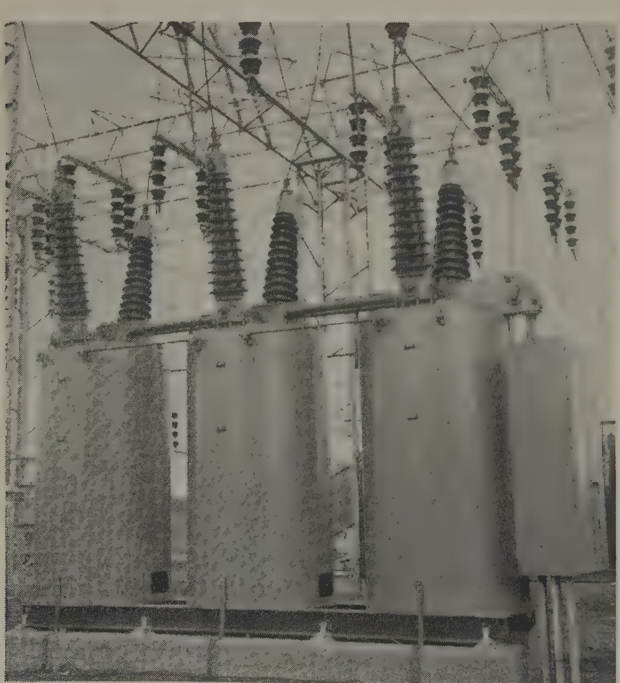

Figure 1. Circuit breaker installation at Johnsonville, Tenn.

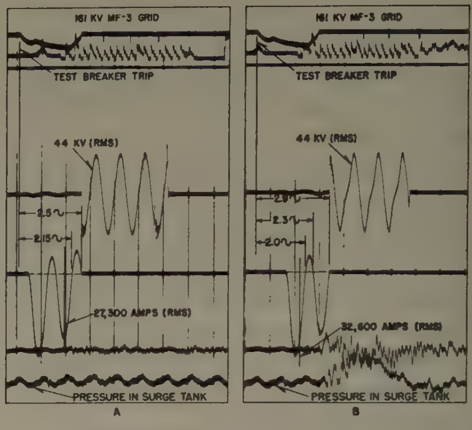

Figure 2. Oscillograms of low- and high-energy interruptions

A new and more powerful mechanically trip-free mechanism was developed to provide high-speed multiple-reclosing performance. Circuit breakers equipped with this mechanism have proved capable of single reclosures in less than 15 cycles and complete triple-reclosing duty cycles in less than $1^1/_4$ seconds.

The oscillograms shown in Figure 2 exemplify the care used in making verification tests as rigorous as possible. In both cases 44 kv were applied to a single interrupter with the current wave completely displaced. In Figure 2*A* the contacts parted in the big loop with the first zero occurring at 2.15 cycles after trip. The contact separation at this time was too short for interruption; consequently, the arc was extinguished at the next current zero which occurred at 2.5 cycles on the end of the small loop. For the oscillogram in Figure 2*B*, the circuit breaker was tripped approximately 0.2 cycle later with respect to the current wave and, due to shorter contact separation, interruption was not possible at the end of the small loop, thus forcing the circuit breaker to arc throughout the subsequent large loop. The current interrupted in this latter case was only 20 per cent in excess of the former; but the recorded pressure in the surge tanks rose to 16 pounds per square inch in the latter and was negligible in the former, indicating the difference in severity of the two interruptions.

From the large number of carefully controlled tests covering all conceivable operating conditions, not only has the service adequacy of this circuit breaker been shown, but also the apparently unlimited possibilities of the dead-tank type of oil circuit breaker have been explored further.

Digest of paper 52-10, "High-Speed Multiple-Reclosing Oil Circuit Breaker for 161 Kv 10,000 Kva," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Electronic Components in Great Britain

G. W. A. DUMMER

Although forward strides have been effected in radar sets and their accomplishments, many problems remain to be solved and this is especially true in the components of the equipment. The British system of Establishments for attacking technical problems is described here together with some of their methods.

FIRST LET US outline the position of the Telecommunications Research Establishment (TRE) in the field of electronic components. There are in England five major research establishments working on radio and radar: Admiralty Signal and Research Establishment—radio and radar for the Navy; Signal Research and Development Establishment—radio for the Army; Radar Research and Development Establishment—radar for the Army; Royal Aircraft Establishment—radio for the Air Force; and TRE—radar for the Air Force.

This last Establishment is organized into three departments: the Physics Department, working on fundamental research; the Radar Department, working on applied radar systems; and the Engineering Department, making experimental models of equipments, testing, and so forth.

In the Engineering Department, work is being done on environmental testing of radar equipments and components and on engineering research on new constructions. All five Establishments maintain similar organizations for their specialized requirements.

The aim since the beginning of 1944 has been to improve the reliability of equipments in service use. The Environmental testing laboratories have analyzed faults occurring in each radar equipment tested with valuable results. We have been fortunate in having since 1946 a Joint Services Testing Schedule which has meant that we can assess progress made towards achieving improved reliability in our equipments. An over-all improvement of four to one has been achieved since 1946. We believe that this Environmental testing, which is compulsory for all manufacturers in the United Kingdom, has contributed a great deal to the improvement in reliability, but it should be stressed that all tests should be carried out on the first production model, so that it will not be too late for modifications to be incorporated in production.

In these tests over 80 per cent of the total faults developing on unsealed equipments are due to poor components and there is, therefore, a group of people working on research and development of new components. The view has been taken that although components must be manufactured by industry, the Research Establishment must be in a position to lead in research on new materials and component techniques. For example, there is work being done at the moment on metal film resistors, dielectric theory, ferrites, and so forth, and in the Physics Department work on semiconductors, theoretical physics, and research on the behavior of materials at liquid hydrogen temperatures.

One or two examples of components work in the United Kingdom have been chosen as illustrations, such as the work on metal film resistors in Figure 1. These are being made experimentally in flatplate, rod, and metallized

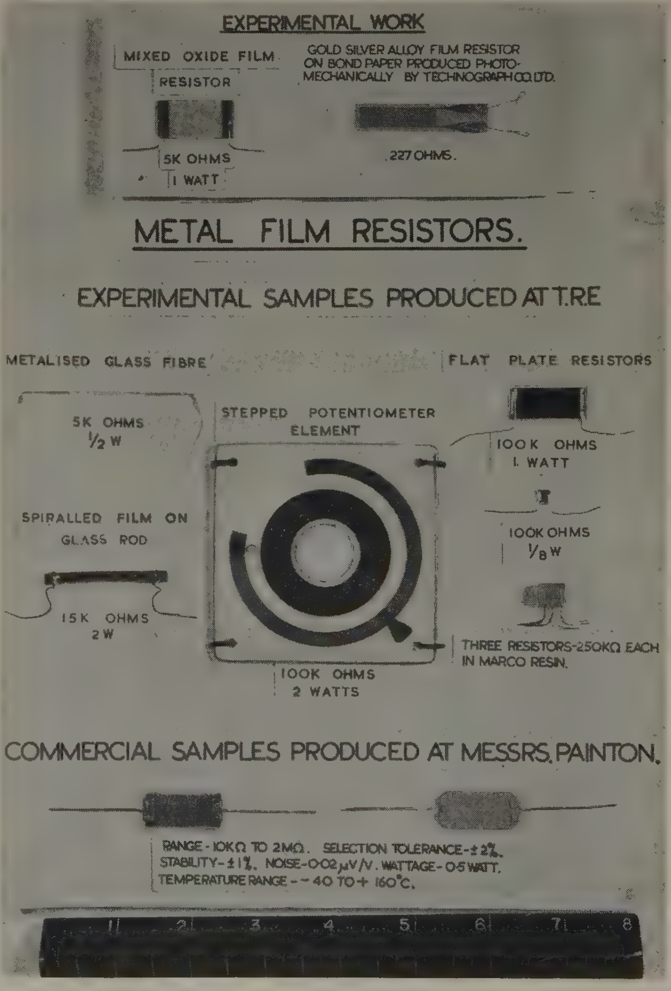

Figure 1. Metallic film resistors in flatplate, rod, and metallized glass-fiber form have been produced experimentally

Revised text of conference paper presented at the Joint AIEE-IRE-RTMA Symposium on Progress in Quality of Electronic Components, Washington, D. C., May 5–7, 1952.

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Figure 2. Many experiments are being conducted on subminiature components such as those shown

0.001-inch glass-fiber form, the resistors being fired platinum and gold solutions with the meander pattern produced by mechanical or photo-etch techniques. Low torque potentiometers and stepless potentiometers also are being made by this method and also experimental tin-antimony oxide films are being deposited on glass bases as resistors.

A precision potentiometer winder has been designed also which will wind toroids to an accuracy of 1 part in 5,000, or 0.02 per cent, on anodized aluminum forms up to 6 inches in diameter. Sintered alumina seals are being used in the United Kingdom for service transformers, in place of silvered ceramic and glass metal seals, Figure 2. They are remarkably robust and show no signs of electrolytic corrosion or mechanical breakages. Finally, a subminiature single change-over relay is being developed which handles 30 watts and is contained in a sealed container in just under a 1/2-inch cube, which is also shown in Figure 2.

There is close co-operation between the Research Establishments of the Navy, Army, Air Force, and Atomic Energy Establishments through the Radio Components Research and Development Committee (RCRDC). Again, any new component for joint service use is developed by a manufacturer and progressed by a responsible officer at one of the Establishments. The RCRDC now places the majority of research, development, and preproduction contracts for new components and is therefore in a strong position to co-ordinate the Services' requirements.

We also have in England a Central Stores for new components and tubes. Deliveries of all new components (closely watched by the Standardization Committee) are made to the Central Stores and any firm holding a development contract can draw new components from this source. Research Establishments draw their supplies of new standardized components from the Stores also.

We have at TRE a small group of people working on new constructional techniques utilizing the experience of the Environmental testing group and using the new components made by the Components Group to construct experimental engineered models of typical radar equipments. The Group deals with such problems as placement and layout of components in chassis, heat dissipation methods, printed and potted techniques, and so forth, and is doing what might be termed engineering research. The Group acts as unbiased and independent advisors on these techniques to other Establishments and Ministries and to radio and allied firms in industry.

There is insufficient space to review the entire field of activities covered by the Establishments, so in Figure 3 are shown examples of work on printed circuit systems, which will give an idea of the state of experimental work in the United Kingdom. The systems shown are an experimental unit-line system of printed circuits in which the wiring can be changed and with automatic solder-dipping of connectors, and a pilot production process using fired silver wiring on drilled glass plates with 16 sprayed resistors automatically adjusted simultaneously in 40 seconds. As far as potted circuits are concerned, some of the leading manufacturers are now in pilot production of potted circuits for the electronic control of air-borne weapons.

While a great deal of interest is shown by British industry, there have not been sufficient specialized applications to warrant the use of printed circuits on a large scale. With the trend toward "unitization" and toward automatic assembly techniques, the value of the printed circuit may yet be realized and considerable experimental work is being done on depositing the common components.

The main advantages to be realized from the use of automatic assembly techniques should be the improvement in reliability. A well-designed machine can work without error and without fatigue; moreover, the drift in the machine can be corrected before the tolerance limits are

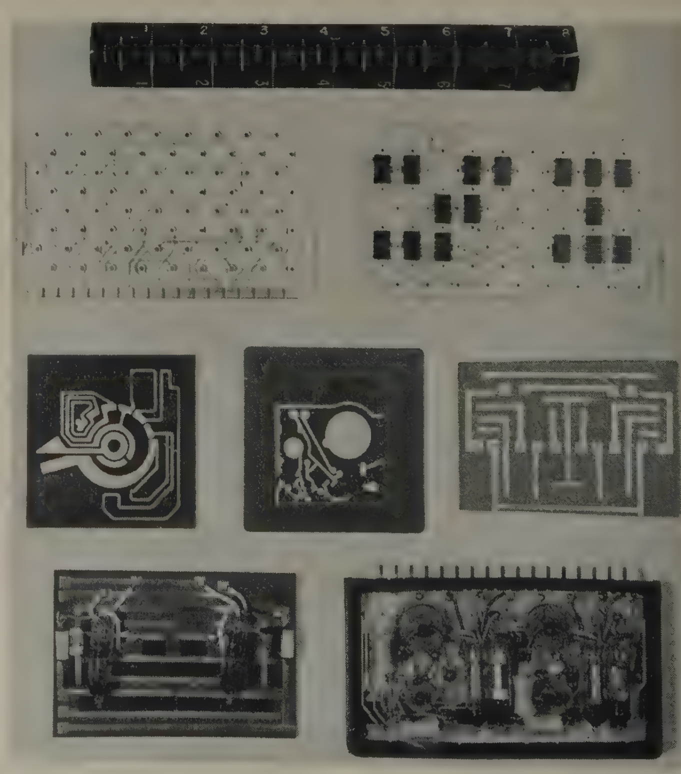


Figure 3. Printed circuits are in the experimental or pilot production stages

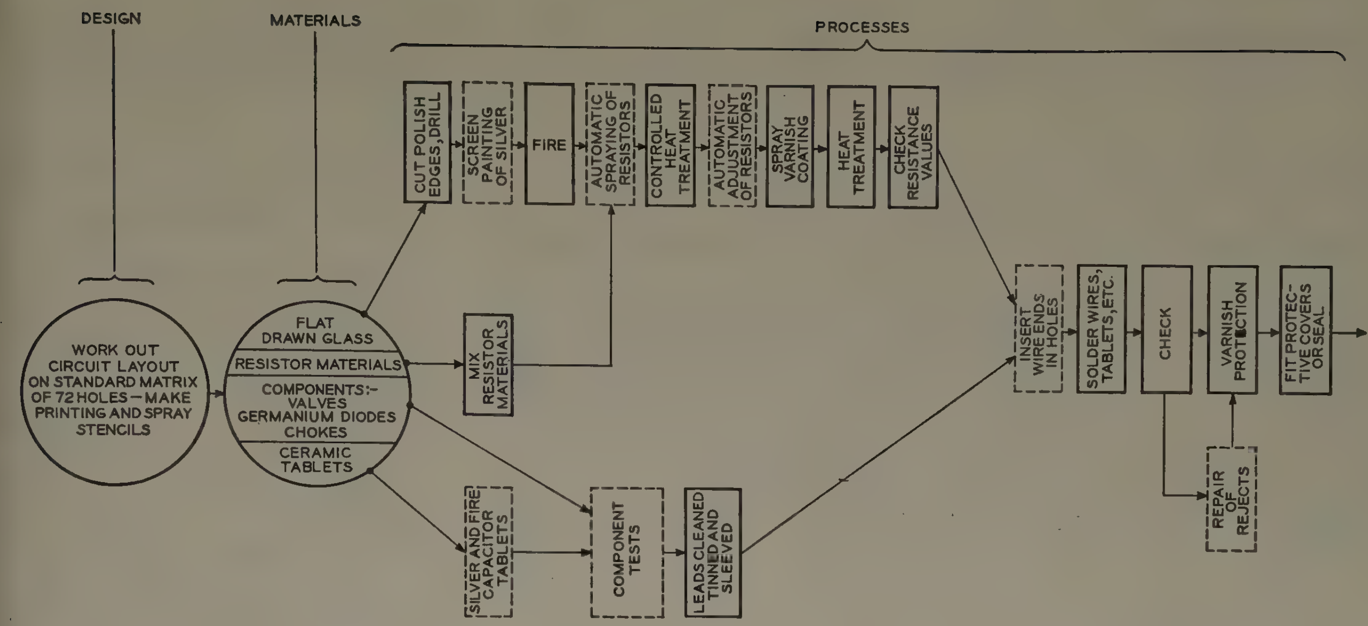


Figure 4. Flow chart of automatic assembly process for a printed circuit in which provision has been made for each stage in the operation to be carried out at the rate of one unit per minute

exceeded. One essential requirement in such machines is that it must be possible to change circuits, components, and so forth, without involving major changes in the production plant. A flow diagram is shown in Figure 4 in which the dotted lines indicate where changes can be made and solid lines show continuous stages.

It should be emphasized that much engineering research is still necessary, particularly on components, before the systems can be regarded as ready for production, but for the large-scale production of reliable subminiature electronic equipments, capable of withstanding world climatic and service conditions, there seems no doubt that the assembly systems of the future will develop from systems similar to those described.

Here we would like to look into the future. With the advent of the transistor and the work on semiconductors generally, it seems now possible to envisage electronic equipment in a solid block with no connecting wires. The block may consist of layers of insulating, conducting, rectifying, and amplifying materials, the electrical functions being connected directly by cutting out areas of the various layers.

Photoelectric Cell Stabilizes Mercury-Arc Lamp Light Intensity

A photoelectric cell which stands watch over a source of light now makes possible for the first time light of unchanging intensity from a high-pressure mercury-arc lamp. Engineers of the Hanovia Chemical and Manufacturing Company recently have combined a special mercury vapor arc lamp with an electric light monitoring system that minimizes any fluctuations in the lamp's output. This new source of highly stable light is finding important uses in photochemical research and motion picture printing.

Light radiated from a high-pressure arc lamp normally varies in intensity owing to factors such as changes in electric supply voltage and in ambient temperatures, or the cooling effects of air drafts.

In the new arc lamp, a photoelectric cell in the power supply controls the arc current through an electronic circuit. Any increase in the light reaching the photoelectric cell causes a reduction in arc current, while a decrease in light results in a stronger arc current. The photoelectric cell, which is continuously monitoring the light output of the mercury-arc lamp, steadily maintains any desired level of light.

The range of light levels at which the stabilized arc can operate is from maximum current to about 10 per cent of maximum for any length of time. These wide limits can be attained because the heat of the electric arc is no longer utilized to maintain the internal vapor pressure, which now depends on auxiliary heating elements. Within these limits instantaneous changes in light level can be made.

The unique freedom from fluctuation characteristic of the new Hanovia lamp as a light source is enabling it to meet successfully such critical applications as the measurement of transmitted light by instruments in photochemical research and also in the printing of sound tracks in motion pictures.

Methods of Electronic Computer Operation Discussed at Joint Conference in New York

New methods of electronic computer operation that should presage extended use in commercial and scientific fields, were discussed by some of the nation's leading authorities at the second annual 3-day Computer Conference and Exhibition sponsored jointly by the AIEE, Institute of Radio Engineers, and the Association for Computing Machinery. The conference was held at the Park Sheraton Hotel, New York, N. Y., December 10–12, 1952, and was attended by more than 1,200 engineers and guests.

The conference featured 27 technical papers on the input and output equipment used in computers. Thirteen manufacturers and scientific organizations displayed equipment used to record and feed information to the huge computing machinery.

Technical lectures and demonstrations originating in the main ballroom were seen in another lecture room two floors above on eight standard home television receivers. This was made possible by the use of the Dage Electronics Company's television camera and equipment and the British Industries Corporation's audio-frequency reproducers and equipment.

The opening session of the conference, at which S. B. Williams, Sylvania Electric Products, Inc., presided, featured a welcoming address by N. H. Taylor, Massachusetts Institute of Technology, who presented a broad picture of what subjects the conference was to cover, that is, the input and output portions of computing equipment.

The only paper given at the opening session was "Recording Techniques for Digital Coded Data" by A. W. Tyler, Eastman Kodak Company. After discussing the characteristics of coded digital computers, five techniques on which recorders might be based were considered: these were perforated paper tape, magnetic tape, printed paper tape, and photographic film and plates.

Dr. M. M. Astrahan, International Business Machines Corporation, was the chairman of the afternoon session, the first paper of which was "Converters Between Teletype Tape and IBM Cards" by G. F. Nielsen, International Business Machines Corporation. In this were described the card-controlled tape punch and the tape-controlled card punch machines and their applications as connecting links between machines using Teletype tape input-output and punched card systems.

E. Blumenthal and F. Lopez, Remington Rand, Inc., described the punched card to magnetic tape converter used for UNIVAC, which was followed by a paper by R. L. Snyder, Jr., on "Devices for Transporting the Recording Media." The final paper of the afternoon was by A. L. Leiner, Electronic Computers Laboratory, on "Buffering Between Input-Output and the Computer" in which were discussed some of the basic methods employed for effecting the transfer of information between input-output equipment and the high-speed memory of digital computers.

The morning and afternoon sessions on Thursday were devoted to considerations of the input and output systems of SEAC, UNIVAC, RAYDAC, and IBM 701 in papers presented by engineers of the National Bureau of Standards, Remington Rand, Inc., Raytheon Manufacturing Company, and International Business Machines Corporation. W. H. MacWilliams, Bell Telephone Laboratories, presided over the morning session and J. H. Howard, Burroughs Adding Machine Company, presided over the one held in the afternoon.

The morning session on the last day of the conference was conducted by J. C. McPherson, International Business Machines Corporation, the first speaker, H. E. Burke, Consolidated Engineering Corporation, presenting a survey of analogue-to-digital converters. The speaker used sketches to illustrate the basic principles of conversion and described an automatic data processing system which showed the advantages which

Shown at the recent Joint Computer Conference and Exhibition in New York, N. Y., are, left to right: Perry Crawford, Jr., Exhibits; J. G. Brainerd, University of Pennsylvania; J. R. Weiner, Publications Committee; S. B. Williams, Association for Computing Machinery Headquarters representative; L. G. Cumming, Institute of Radio Engineers Headquarters representative; C. V. L. Smith, Office of Naval Research; N. H. Taylor, General Conference Chairman; J. C. McPherson, Finance Committee; F. J. Maginess, General Electric Company; J. H. Howard, Secretary; A. R. Mohr, Local Arrangements; R. S. Gardner, AIEE Headquarters representative

Future AIEE Meetings

AIEE–IRE–ACM Western Computers Conference
Statler Hotel, Los Angeles, Calif.
February 4–6, 1943

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 20–21, 1953

Southern District Meeting
Seelbach Hotel, Louisville, Ky.
April 22–24, 1953
(*Final date for submitting papers—closed*)

North Eastern District Meeting
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
(*Final date for submitting papers—closed*)

AIEE–IRE–RTMA–WCEMA West Coast Electronic Conference
Shakespeare Club, Pasadena, Calif.
April 29–May 1, 1953

Summer General Meeting
Chalfont-Haddon Hall Hotel, Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—March 17*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 3*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

can result from instrumentation designed around an analogue-to-digital converter.

"Survey of Mechanical Type Printers" was presented by J. Hosken, A. D. Little, Inc., and this was followed by a "Survey of Nonmechanical Printers" by Lieutenant R. J. Rossheim, George Washington University. A description of high-speed printing equipment was given by L. Rosen, ANelex Corporation.

R. G. Thompson and C. E. Hunt, Jr., Eastman Kodak Company, presented "The Eastman Printer." This nonphotographic electromechanical equipment operates from a coded signal, supplied from any suitable source, as from the holes in automatically fed punched cards, film, perforated tape, magnetic tape or wire, radio, electronic computer, electronic storage, and so forth.

The afternoon session was presided over by Dr. J. G. Brainerd, University of Pennsylvania, and the first speaker, B. W. Pollard, Ferranti, Ltd., London, England, described that firm's input-output equipment. This was followed by O. G. Hessler, Sears Roebuck Company, who presented "Garment Tag Equipment."

"A Numerically Controlled Milling Machine," by J. O. McDonough and A. K. Susskind, Massachusetts Institute of Technology, was a description of the equipment now in operation at the Servomechanisms Laboratory.

Dr. S. N. Alexander, National Bureau of Standards, gave the final paper, "Summary and Forecast," which was followed by a period of informal discussion.

The chairman of the national committee is N. H. Taylor; J. C. McPherson, Finance Committee; J. H. Howard, Secretary; S. N. Alexander, Program Committee; J. R. Weiner, Publications Committee; A. R. Mohr, Local Arrangements; P. Crawford, Exhibits; A. C. Holt, Registration; E. G. Andrews, Hotel Arrangements; W. Eisele, Audio-Visual Committee; B. F. Osbahr, Publicity; and R. R. Batcher, Treasurer and Finance Committee.

North Eastern District Meeting Committee

Members of the Planning Committee for the AIEE North Eastern District Meeting, which will be held in Boston, Mass., April 29–May 1, are, front row, left to right: J. C. Hitt, Hotel Arrangements; L. J. Weed, Secretary-Treasurer, Boston Section; F. B. Haeussler, General Chairman; Mrs. G. J. Crowdes, Ladies' Activities; Mrs. L. J. Weed, Ladies' Activities; G. J. Crowdes, Secretary. Back row, left to right: A. L. O'Banion, Registration; C. A. Powel, Past President, AIEE, and Counselor; F. D. Snyder, Technical Program; L. T. Jester, Jr., Publicity; W. A. Carlson, Banquet and Smoker; W. F. Potter, Vice-Chairman, Boston Section; E. W. Boehne, Chairman, Boston Section

1953 Southern District Meeting Will Be Held in Louisville, Ky.

With the Hotel Seelbach, located in the heart of downtown Louisville, Ky., as headquarters, the 1953 Southern District Meeting of the Institute will be held April 22–24. Excellent facilities are awaiting those attending the meeting; all meeting rooms and many of the guest rooms are air conditioned.

Rooms also will be available at various other hotels within walking distance of meeting headquarters, and arrangements have been made for dormitory-type rooms at the Seelbach for students. The Belknot Campus of the University of Louisville is within 15 minutes of the hotel. Several of the student meetings will be held on the campus at the university's Speed Scientific School.

Many interesting inspection trips are being arranged in conjunction with the meeting. Louisville industry includes hydro and steam generation plants, high-frequency dielectric heating equipment manufacturing, cigarettes and tobacco products, distilleries, automobile assembly plants, furniture manufacturing, railroad diesel repair shop, chemical manufacturing including paints, varnishes, and synthetic rubber, printing, and television and radio stations. Louisville's most unusual enterprise is the American Printing House for the Blind. It is the oldest national institution for the blind and the largest Braille publishing house in the world.

Churchill Downs, home of the Kentucky Derby, is a few minutes from the Louisville campus. The Spring Racing Meet will be starting on April 25, following the meeting.

Professor M. G. Northrup of the University of Louisville is the General Chairman for the Southern District Meeting.

AIEE Nominating Committee Meets in New York City

The Nominating Committee of the AIEE met at the Hotel Statler, New York, N. Y., on January 21, 1953, during the Winter General Meeting of the Institute to nominate candidates for AIEE offices to be voted on by the membership in the spring of 1953. Members of the committee are as follows.

Representing the Board of Directors:

R. F. Danner, Oklahoma Gas and Electric Company, Oklahoma City, Okla.

M. D. Hooven, Public Service Electric and Gas Company, Newark, N. J.

N. C. Pearcy, Pioneer Service and Engineering Company, Chicago, Ill.

C. S. Purnell, Westinghouse Electric Corporation, New York, N. Y.

W. R. Way, Shawinigan Water and Power Company, Montreal, Quebec, Canada

Representing the ten geographical Districts:

1. E. W. Boehne, Massachusetts Institute of Technology, Cambridge, Mass.
2. F. B. Crider, General Electric Company, Washington, D. C.
3. J. A. Parrott, American Telephone and Telegraph Company, New York, N. Y.
4. E. S. Lammers, Jr., Westinghouse Electric Corporation, Atlanta, Ga.
5. J. R. North, Commonwealth Services, Inc., Jackson, Mich.
6. A. E. Paige, University of Denver, Denver, Colo.
7. J. B. Thomas, Texas Electric Service Company, Fort Worth, Tex.
8. W. L. Carter, Pacific Telephone and Telegraph Company, San Francisco, Calif.
9. L. B. Stacey, Packard Electric Company, Vancouver, British Columbia, Canada
10. B. G. Ballard, National Research Council, Ottawa Ontario, Canada

Alternates for Board representatives:

E. W. Davis, Simplex Wire and Cable Company Cambridge, Mass.

C. M. Lytle, Kansas City Power and Light Company Kansas City, Mo.

J. C. Strasbourger, Cleveland Electric Illuminating Company, Cleveland, Ohio

Alternates for District representatives:

6. F. B. Eastom, University of Colorado, Boulder, Colo.
7. O. S. Hockaday, Texas Electric Service Company Fort Worth, Tex.

Board of Directors Approves Revisions in Standards

The Boards of Directors of the AIEE and The American Society of Mechanical Engineers (ASME) have approved revisions of AIEE Standards *601* and *602* and ASME Standard *100*, "Preferred Standards for Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generators (Larger than 10,000-Kw Rated Capacity)."

Major changes in the Standards are:

1. The expression "Turbine Capability"

has been eliminated. The figures that were previously used as the turbine capability are now called "Turbine Rating." This decision resulted from a feeling that confusion existed in the industry because of a turbine rating of one figure with a capability of 10 per cent greater. The trend in the United States and abroad has been to use only a single rating and this has been selected as that of the old capability. This has meant a revision of the saturation temperatures at the various extraction openings to correspond with the new rating.

2. The rating of the previously selected largest machine of 99,000 kw capability has been changed to 100,000 kw in order to round out the figure. This has meant slight changes in the rating of the generator.

3. A new turbine has been added with a rating of 150,000 kw. The generator rating on this machine bears the same relation to the turbine rating as on the existing machines. This is a reheat machine 1,800 pounds per square inch gauge throttle pressure, 1,000/1,000 degrees Fahrenheit temperature with seven extraction openings. The voltage of the new generator has been established at 18,000 volts.

4. All hydrogen-cooled generators have been made suitable for 30 pounds per square inch gauge hydrogen pressure and have been given capabilities at this pressure of 25 per cent above the rating at 0.5 pound per square inch gauge hydrogen pressure.

5. The paragraph on "Excitation" has been made more strict in requiring that the exciters shall operate within their voltage rating with the generators operating at their 30 pounds per square inch gauge hydrogen pressure capability.

6. Editorial changes have been made throughout as necessary and the preliminary paragraphs have been revised to explain the development of the Standards.

The essential characteristics of the turbine-generators are shown in Table I.

BPA Engineer Addresses Meeting of Richland Section

Some 60 engineers from southeastern Washington and northeastern Oregon attended a meeting of the AIEE Richland Section in Richland, Wash., on November 24, 1952. Robert P. Walters, Area Engineer for the Bonneville Power Administration's southeast area, was guest speaker.

Mr. Walters showed two films, "Stringing and Sagging," and "25,000 Volts Under the Sea," and followed each by a question and answer period. In his discussion he pointed out that, at the present time, most of the power in the Northwest is generated east of the Cascades, while most of the demand lies on the west side. This requires long transmission lines across the state. He also discussed the relative merits of aluminum and copper conductors, and other items of interest regarding transmission-line construction.

The second film showed the construction and installation of the world's largest submarine cable. This cable, which was manufactured by the Okonite Corporation, is $4^2/_3$ inches in diameter and 7 miles long. It was shipped from the east, in special railroad cars, and laid under Puget Sound to carry power from the mainland to the San Juan Islands.

New Adirondack Subsection Offers Publicity Suggestions

In an effort to present the activities of the AIEE before the general public, the newly formed Adirondack Subsection of the AIEE Schenectady Section recently secured a radio interview and also a service club luncheon address for a visiting AIEE speaker.

The speaker, W. C. Brown of the General Electric Company, Cleveland, Ohio, addressed a meeting of the Subsection on November 25, 1952. In conjunction with the meeting, the Adirondack Subsection arranged with the Glens Falls, N. Y., radio station *WWSC* to make a recorded 15-minute interview without financial obligation, to be broadcast at a later time over that station. To ensure that the radio interview would have general appeal to the listening public, and also to acquaint the public with the aims and scope of the AIEE, a list of questions was prepared in advance by C. L. Amick of the General Electric Company in Cleveland.

W. C. Brown of the General Electric Company's Lamp Division points out 73 years of progress by comparing a replica of the Edison lamp and a modern type, during his address before the Adirondack Subsection of the AIEE on November 25, 1952, in Glens Falls, N. Y.

Another means of bringing the Institute before the public was accomplished by arranging with the Glens Falls Lions Club to invite Mr. Brown to address them at their regular luncheon. His talk on lighting, and interesting displays, were enthusiastically received, with full recognition given to his scheduled appearance before the AIEE. Local newspapers ran complete accounts of

Table I. Preferred Standards for Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generators

	Air-Cooled Generator	Hydrogen-Cooled Generators Rated for 0.5 Psig Hydrogen Pressure									
Turbine rating*, kw	12,650	16,500	22,000	33,000	44,000		66,000		100,000††		150,00
Generator rating, kva	13,529	17,647	23,529	35,294	47,058	47,058	70,588	70,588	106,951	106,951	160,42
Power factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Short-circuit ratio	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.8	0.8	0.8
Throttle pressure, psig	600	850	850	850	850	1250	850	1250	1450	1450†	1800†
Throttle temperature, F	825	900	900	900	900	950	900	950	1000	1000	1000
Reheat temperature, F										1000	1000
Number of extraction openings	4	4	4	5	5	5	5	5	5	5	7
Saturation temperatures at openings at "turbine rating" with all extraction openings in service, F											
1st	180	180	180	180	180		180		185	180	150
2d	240	240	240	240	240		240		250	245	185
3d	290	290	290	290	290		290		310	305	235
4th	360	360	360	360	360		360		385	375	280
5th				420	420		420		450	450	325
6th											375
7th											455
Exhaust pressure, inches Hg. abs	1.5	1.5	1.5	1.5	1.5		1.5		1.5	1.5	1.5
Generator capability at 0.85 power factor and 15 psig hydrogen pressure, kva		20,294	27,058	40,588	54,117		81,176		122,994		184,49
Generator capability at 0.85 power factor and 30 psig hydrogen pressure, kva		22,059	29,411	44,118	58,822		88,235		133,689		200,53

A tolerance of 10 degrees Fahrenheit shall apply to above saturation temperatures. Tolerances shall be unilateral, if possible, so as not to reduce the spread in temperatur between adjacent extraction openings.

* The "turbine rating" is guaranteed continuous output at generator terminals when the turbine is clean and operating under specified throttle steam pressure and temperatur and 2.5 inches Hg abs exhaust pressure, with full extraction from all extraction openings.

† A 10-per-cent pressure drop is assumed between high-pressure-turbine exhaust and low-pressure-turbine inlet for the reheat machines.

†† These are two different turbines; the first for regenerative-cycle operation, and the second a machine for reheat-regenerative-cycle operation.

Mr. Brown's visit, with full publicity given to the Institute as well as the Lions Club. The papers also carried an announcement of the *WWSC* broadcast.

Because of the favorable results obtained in the foregoing instance, similar arrangements were made for Philip Klass, Avionics Editor of *Aviation Week*, who addressed the Adirondack Subsection on January 15, 1953.

Pittsburgh Section Holds Golden Jubilee Dinner

AIEE President D. A. Quarles was the principal speaker at the Golden Jubilee Dinner of the AIEE Pittsburgh Section held on December 4, 1952. The dinner marked the 50th year of the Section, the third Section formed in the Institute.

The first technical meeting of the Pittsburgh Section was held on December 4, 1902, in the Westinghouse Electric Club Rooms in Wilkinsburg, Pa., and the first officers were P. M. Lincoln (later president of the Institute) as chairman, J. S. Peck as secretary, and H. W. Fisher, C. W. Rice, and S. M. Kinter, in charge of programs and meetings. Eleven of the 79 Institute members in the Pittsburgh district at the end of 1902 are still members, and three of these men are living in Pittsburgh today: W. K. Dunlap, retired; Ludwig Hommel, president of Ludwig Hommel and Company; and H. D. James, Consulting Engineer.

In his address, Mr. Quarles reviewed some of the problems of the Institute and pointed to the rapid growth of its membership. In the Pittsburgh Section, for example, there were 19 members and 120 guests at the first organization meeting 50 years ago. Today the Section has grown to 1,336, making it the sixth largest Section in the Institute. J. C. Strasbourger, Vice-President, District 2, spoke briefly and then presented certificates to prize winners from that District for outstanding technical papers.

One of the highlights of the meeting was the presentation of the gavel used at the first technical meeting of the Section in 1902 by H. D. James, who was in attendance at the original meeting.

Preceding the anniversary meeting, a student conference was held in the auditorium of the Springdale power station of the West Penn Power Company, after an inspection trip through the station. Each year the Pittsburgh Section awards $75 in prizes for the best technical papers from the four universities in the Pittsburgh district: Pennsylvania State College, University of Pittsburgh, Carnegie Institute of Technology, and West Virginia University. Awards were made at the Jubilee Dinner to the prize winners, the first prize going to P. K. Eckman, Carnegie Institute of Technology, for his paper, "Exploding Wires—A High-Intensity Light Source." Second prize went to John Fridrick, Pennsylvania State College, for "Stability Templates for Feedback Amplifiers."

Among those present at the Golden Jubilee Dinner of the Pittsburgh Section on December 4 were (left to right): H. D. James, Pittsburgh Consulting Engineer who was present at the first technical meeting of the Section in 1902; W. J. Lyman, Chairman, Pittsburgh Section; J. C. Strasbourger, Vice-President, District 2; D. A. Quarles, President, AIEE

Summer General Meeting Committee

The 1953 Summer General Meeting of the Institute will be held in Atlantic City, N. J., June 15–19. Shown conferring on plans for the coming meeting are, seated, left to right: A. C. Muir, General Committee; J. B. Harris, Chairman, Entertainment Committee; L. R. Gaty, Chairman, General Committee; W. F. Henn, Vice-Chairman, General Committee; R. W. Wilbraham, Treasurer, and Chairman, Finance Committee; J. B. Taylor, representing B. L. England, Vice-Chairman, General Committee. Standing, left to right: T. E. Stieber, Chairman, Registration Committee; R. M. Pfalzgraff, General Committee; M. L. Stoughton, Chairman, Publicity and Promotion Committee; Dr. W. R. Clark, Technical Program Committee; Dr. S. R. Warren, Chairman, Students Activities Committee; W. G. Salmonson, Chairman, Transportation Committee; H. F. Davis, Chairman, Hotels Committee. Committee members not present are W. F. Denkhaus, Chairman, Arrangements Committee, and A. D. Brown, who is Chairman of the Sports Committee

AIEE Philadelphia Section to Observe 50th Anniversary

The AIEE Philadelphia Section will celebrate its 50th anniversary with a Golden Jubilee dinner-meeting on February 9, 1953.

In honor of the history and accomplishments of this Section, Horace P. Liversidge, Chairman of the Board, Philadelphia Electric Company, will reminisce. A number of charter members and past chairmen of this Section are also expected to attend and participate in the meeting.

L. R. Gaty, Chairman of the Philadelphia Section, will preside over the dinner-meeting, at which J. C. Strasbourger, District 2 Vice-President, will speak on "The AIEE Becomes of Age." A second scheduled paper, to be presented by M. C. Benedict of the Westinghouse Electric Corporation, is entitled "Development and Application of Jet Engines to Airplanes."

The dinner tables and meeting room will be appropriately decorated and special ceremonies will be held to commemorate the 50 years of this Section's activities. Reservations for the dinner should be made in advance, as a large attendance of old and new members, and guests, is anticipated for this affair.

Electronic Components Symposium Scheduled for Pasadena, Calif.

According to a recent announcement, the 1953 Electronic Components Symposium will be held on April 29, 30, and May 1 at the Shakespeare Club in Pasadena, Calif. This symposium is one in a series of national yearly meetings on electronic component parts, and is expected to attract more than 1,000 scientists, engineers, technical workers, and executives interested in future developments of the electronics industry.

The symposium will be sponsored by the AIEE, Institute of Radio Engineers, Radio-Television Manufacturers' Association, and the West Coast Electronic Manufacturers' Association. Sessions will follow the general pattern of previous national meetings on electronic component parts held in Washington, D. C., and Los Angeles, Calif.

Dr. A. M. Zarem, Chairman of the Executive Committee for the symposium, has pointed out that the purpose of this meeting is to bring together all those who share an interest in the development, design, performance, and future of electronic components. The importance of reliability and performance of components will be covered. According to Dr. Zarem, it is hoped that "this meeting will assist in a better understanding of the important problems being faced by the electronic industry in producing components and equipment essential to the extreme demands placed upon it by military requirements in the field of missiles and aviation, and by industrial requirements in the fields of controls, instrumentation, and television."

Headquarters for the Electronic Components Symposium have been established at the Stanford Research Institute, Suite 1011, 621 South Hope Street, Los Angeles 17, Calif.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Air Transportation (*D. E. Fritz, Chairman; W. L. Berry, Vice-Chairman; L. R. Larson, Secretary*). This committee held its annual business meeting October 31, 1952, in conjunction with the Middle Eastern District Meeting in Toledo, Ohio. Five technical sessions were presented, including 26 interesting and timely papers.

The committee decided to hold a technical conference in Seattle, Wash., in the fall of 1953, at the invitation of the Seattle Section. Papers for this meeting are presently being solicited.

Subcommittees have held several meetings during the past year and expect to issue test codes on aircraft circuit interrupting devices and on aircraft carbon pile regulators in the near future.

A new subcommittee was initiated to study and formulate dielectric testing standards for aircraft electric apparatus, under the chairmanship of J. P. Dallas.

The test code for aircraft d-c rotating machinery has been revised and is currently being submitted to the Standards Committee. A new test code for aircraft a-c rotating machinery is currently under preparation, as is a study of the methods of presenting test and application data on rotating machines.

Power Division

Committee on Transformers (*F. J. Vogel, Chairman; M. K. Brown, Vice-Chairman; J. R. Meador, Secretary*). The dielectric test values are being reviewed so that they may be brought up to date. This work is nearly complete, and recommendations for revising tables should be available soon.

A study of service requirements and of the dielectric properties of the transformer insulation is in progress also, for possible future use. This is of greater than usual interest because of the increase in operating voltages of new systems.

From its use in maintenance work, the question of insulation power factor has arisen in so far as it applies to new units. It has been agreed that some steps should be taken to provide a test code, so that some standardization of test methods would result. There has been some discussion as to whether limiting values should be set up, but there is a majority against such action.

Transformer noise is being studied, to see if present methods of measurement are satisfactory, and if anything can be done to reduce it. It is a difficult subject and one in which progress will be made slowly.

A project group on current-limiting reactors has nearly completed its work and its recommendations also will be sent to the Standards Committee soon. It has involved questions as to maximum short-circuit currents and insulation aging due to them.

Classifications of insulation for dry-type transformers, and temperature limits are of great interest, and are both being studied and tested in various laboratories. This is a similar effort to those in other Institute committees, and it has been the subject of many papers and a conference at the Winter General Meeting.

Science and Electronics Division

Committee on Metallic Rectifiers (*W. F. Bonner, Chairman; Glen Ramsey, Vice-Chairman; E. A. Harty, Secretary*). The committee's annual meeting was held during the Winter General Meeting of the AIEE at which time the six subcommittees presented results of their work during the past 12 months.

The committee, in co-operation with the Committee on Electronic Power Converters, presented a report on the status of the metallic rectifier industry in conjunction with the May 19–20 meeting in Pittsburgh, Pa., which is now known as the AIEE Conference on Electronic Converter Applications and Tubes. This report is published as Publication *S-50*.

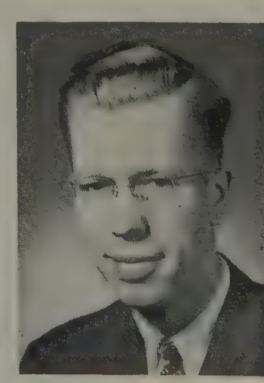
Joint Subcommittee on Electronic Instruments. Work of the subcommittee during 1952 was concentrated on the completion of the Specification Outlines for Cathode-Ray Instruments, Vacuum Tube Voltmeters, and Signal Sources. Late last summer, the final draft prepared by the committee was sent to the members of the Electronics and Instruments and Measurements Committees with request for comments.

Work is continuing in the Task Group on Cathode-Ray Instruments in co-operation with the Institute of Radio Engineers (IRE) Committee on Cathode-Ray Oscillography. This combined IRE-AIEE committee is working on definitions and is making good progress.

It was proposed to draft Specification Outlines for Tube Testers.

AIEE PERSONALITIES.....

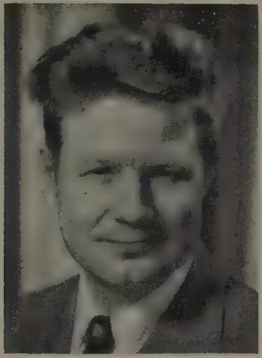
G. W. Staats (AM '43) engineer, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been cited for honorable mention in the 1952 Eta Kappa Nu Recognition of the Outstanding Young Electrical Engineer. Born November 30, 1919, in Forest Park, Ill., he was graduated from Illinois Institute of Technology in 1942 with the best scholastic average in the electrical engineering department. He joined Allis-Chalmers Manufacturing Company as a student engineer and after completion of the training course he took a permanent assignment in the a-c engineering group of the motor and generator section. During the war he made designs and supervised tests and drafting work on salient-pole synchronous machines and induction motors. In 1946 he went back to Illinois Institute of Technology as a graduate student, having been awarded the Allis-Chalmers–Illinois Institute of Technology fellowship in power systems engineering. After receiving his master of science degree in electrical engineering, he returned to Allis-Chalmers in 1948 assigned to the steam turbine-generator engineering group. He became engaged in the development of supercharged ventilation of turbine-gener-



G. W. Staats

ators and made major contributions to this development. In September 1952 he became head of the group responsible for the design of supercharged machines. Mr. Staats is a member of Eta Kappa Nu and Tau Beta Pi and has served as assistant chairman of a discussion group of the Milwaukee Section of the AIEE.

E. O. Johnson (AM '52), research engineer, RCA Laboratories Division, Radio Corporation of America, Princeton, N. J., has been cited for honorable mention in the 1952 Eta Kappa Nu Recognition of the Outstanding Young Electrical Engineer. He was born in Hartford, Conn., December 21, 1919. He entered Pratt Institute as a candidate for an electrical engineering degree, but was called for service in the United States Navy. In October 1945 he



E. O. Johnson

returned to Pratt to continue his studies. While there he won a Westinghouse Achievement Award for scholarship. The first 6 months after his graduation in February 1948 he spent as a laboratory and research assistant at Pratt. In the summer of 1948 he joined the RCA Laboratories at Princeton, N. J., as a research engineer in the field of gaseous electronics. These studies led to a new type of gas tube, the Plasmatron, which has the ability continuously to control large currents in low-voltage circuits. At present he is in charge of a government project at RCA for the development of a device which stems from his research in the field of gaseous electronics. Mr. Johnson is a member of the Institute of Radio Engineers, Sigma Xi, and Tau Beta Pi. He is a member of the AIEE Subcommittee on Electron Tubes.

H. R. Pearson (AM '36, M '41), head, personnel department, Dallas (Tex.) Power and Light Company, has been elected a vice-president of Region VIII of The American Society of Mechanical Engineers. A native of Taylor, Tex., Mr. Pearson received his engineering education at the University of Texas, where he received a bachelor of science degree in mechanical engineering 1926. After graduation he spent a year with Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) at Philadelphia, Pa. In 1927 he started with Dallas Power and Light Company as plant betterment engineer with the responsibility of mechanical and electrical test work at the Dallas Steam Electric Station. He became head of operation at this station in 1933. In 1934 he was transferred to the Engineering Department and made responsible for engineering in connection with generating stations, substations, and transmission lines. Mr. Pearson was given the responsibility for the development of an industrial relations program in the company during 1944 and still heads the department, covering employee and labor relations. Mr. Pearson is a registered professional engineer and a member of the Edison Electric Institute. He is a past chairman of the North Texas Section of the AIEE.

W. C. Sealey (M '38, F '48), engineer-in-charge, Transformer Design Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named chief engineer of the transformer section. Mr. Sealey came to Allis-Chalmers in 1931 and has been in charge of the transformer engineering section since 1941. He is a member of the Engineers' Society of Milwaukee, and a registered engineer. **K. P. Wiederkehr** (AM '38, M '45), electrical engineer, has been appointed engineer-in-charge of transformer design. He has been with Allis-Chalmers transformer section since 1924. He received his electrical engineering degree from the State College of Zurich, Switzerland, and worked for several manufacturers in that country before coming to the United States. **R. P. Marohn** (AM '38), electrical engineer, has been appointed engineer-in-charge of regulator design, transformer section. He came to Allis-Chalmers in 1923 after graduating as an electrical engineer from Lewis Institute. He has been connected continuously with the transformer section. Mr. Sealey has served on the following AIEE committees: Electric Machinery (1942–47); Electronic Power Converters (1947–52); and Transformers (1947–52).

G. M. Pollard (AM '25, M '34), system operating engineer, Niagara Mohawk Power Corporation, Syracuse, N. Y., has been named general superintendent of all electrical operations of the company. Mr. Pollard is a graduate of Cornell University and joined Niagara Mohawk Power as engineer in the steam plant design department in Buffalo, N. Y., in 1923. In 1929 he was named Buffalo district assistant superintendent of the substations department, becoming general superintendent of substations in 1936. Four years later he became superintendent of operations for the Buffalo district and in 1945 he was appointed assistant operations manager for the Western division. He has been system operating engineer since January 1950. He has served on the Power Generation Committee of the Institute (1939–48).

E. E. DeMarsh (AM '48), sales manager, Burndy Engineering Company, Inc., New York, N. Y., has been elected vice-president in charge of sales. Mr. DeMarsh, a member of the board of directors since 1948, has been associated with Burndy for 16 years, the past 4 years as sales manager. He is a native of Cohoes, N. Y., and an electrical engineering graduate of Rensselaer Polytechnic Institute. Before joining Burndy in 1936, he was in the electrical contracting business and also was with United Electric Light and Power Company, now part of Consolidated Edison Company of New York. He is a member of the American Ordnance Association, a representative to National Electrical Manufacturers' Association, and vice-president of Electrical Service Connector Institute.

J. L. McKeever (AM '32, M '47), works engineer, Peterborough Works, Canadian General Electric Company, Peterborough, Ontario, Canada, has been appointed manager, engineering department, Apparatus Division. Mr. McKeever attended the University of British Columbia. He joined the Induction Motor Engineering Division of Canadian General Electric and was transferred to A-C-D-C Engineering in 1935. Three years later he was appointed general engineer. He headed the Industrial and Central Station Engineering section until his appointment as works engineer. He is a member of the Engineering Institute of Canada, the Canadian Electrical Association, and the Canadian Committee of the International Electrotechnical Commission. He has served on the Industrial Power Systems Committee of the AIEE (1947–52).

F. M. Parsons (M '50), sales manager, Kellogg Switchboard and Supply Company, Chicago, Ill., has been elected a vice-president of the company, which is an associate of International Telephone and Telegraph Corporation. Mr. Parsons became affiliated with the Kellogg Company in 1923, but left in 1928 to take over the position of superintendent, telephone division, Central Western Public Service Company, Omaha, Nebr. Rejoining Kellogg in 1934, he served successively as manager of its switchboard sales department, supervisor of field representatives, and eastern sales manager. During World War II he served as the company's government representative in Washington, D. C. He was appointed sales manager in 1944.

D. E. Fritz (AM '43, M '50), chief engineer, Jack and Heintz Precision Industries, Inc., Cleveland, Ohio, has been appointed director of engineering and assistant to the president. Mr. Fritz has been chief engineer for the past 3 years. He joined the company in 1948 as manager of the special aviation projects section. Previously he was manager of the rotating apparatus section, aviation engineering department, at the Lima, Ohio, plant of Westinghouse Electric Corporation. Mr. Fritz has served on the following AIEE committees: Air Transportation (1947–53, Chairman 1951–53); Rotating Machinery (1949–53); General Applications Division (1951–53); and Liaison Representative on Standards Committee (1951–53).

G. F. Eckenstaler, Jr. (AM '51) has completed the graduate training course at the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., and has been assigned to the electronics section of the power department. Mr. Eckenstaler is a graduate of the

University of Illinois. **Donald Williams** (AM '51) and **P. I. Nippes** (AM '51) have been assigned to the company's motor and generator section. Mr. Williams received his degree from Michigan College of Mining and Technology, and Mr. Nippes is a graduate of Pennsylvania State College. **J. L. Grim** (AM '51), **J. A. Keymar** (AM '51), and **S. E. McDowell** (AM '51) have been assigned to the substation section. Mr. Grim is a graduate of Clarkson College of Technology, Mr. Keymar of the University of Wisconsin, and Mr. McDowell of the University of Michigan. Mr. McDowell is a member of the American Society of Naval Engineering. **F. H. Ladd** (AM '51), **S. R. Lindgren** (AM '51), and **R. E. Horn** (AM '52) have been assigned to the transformer section. Mr. Ladd received his degree from Tufts College, Mr. Lindgren from Kansas State College, and Mr. Horn from Marquette University.

J. W. Timmerman (AM '43), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed assistant chief engineer of the switchgear section. A graduate of the University of South Dakota, he joined Allis-Chalmers switchgear section in 1946. In 1949 he became assistant engineer in charge of design. **Albert Ewy** (AM '43), switchgear engineer, has been named engineer-in-charge of switchgear design. Mr. Ewy came to Allis-Chalmers in 1930 following graduation as an electrical engineer from the University of Minnesota. He completed the company's gradutae training course and has been with the switchgear engineering department since 1936. **J. H. Michael** (AM '26, M '39), design engineer, has been named engineer-in-charge of switchgear development. Mr. Michael received his electrical engineering degree from the University of Wisconsin in 1924 and came to Allis-Chalmers the same year. He has worked in the switchgear section as a draftsman and designer, engineers' assistant, assistant engineer, and switchgear design engineer. He is a member of the Engineers' Society of Milwaukee.

R. B. Hubbard (AM '20, M '28), secretary-manager, Rocky Mountain Electrical League, Denver, Colo., has been elected president of the International Association of Electrical Leagues. Last year he was vice-president of the board of governors and before that treasurer. Mr. Hubbard, on leave from the Public Service Company of Colorado, Denver, started in 1913 as a junior engineer with Denver Gas and Electric Company, a predecessor company of Public Service. After 2 years with Denver Gas and Electric, he went to H. L. Doherty and Company, New York, N. Y., remaining until 1917. Later he became superintendent at Boulder, Colo., for Western Light and Power Company. From 1930 to 1933 Mr. Hubbard served as staff engineer for Public Service at Denver, then he went on to become director of the industrial development department. In 1945 he was granted a leave of absence from Public Service to assume the Rocky Mountain Electrical League duties. Mr. Hubbard is a past president of the Colorado Society of Engineers and chairman of the Denver Section of the AIEE.

C. P. Hayes (AM '41), manufacturing engineer, Manufacturing Services Division, General Electric Company, Schenectady, N. Y., has been appointed manager of sales analysis and product inventory control, Major Appliance Division, Louisville, Ky. Mr. Hayes, who was graduated from the University of North Carolina in 1931 with a bachelor of science degree in electrical engineering, joined General Electric as a test engineer in Schenectady in January 1932. In 1935 he was transferred to transformer and motor design at the Fort Wayne, Ind., works. From 1939 to 1946 he held various supervisory assignments in the fractional-horsepower motor department at Fort Wayne and in 1946 was named engineer of the ballast section at Fort Wayne. In 1949 Mr. Hayes was appointed staff assistant to the manager of engineering of the small apparatus division in Lynn, Mass., and held that position until his transfer to Schenectady.

J. M. McElwee (M '45), Kellex Corporation, New York, N. Y., has been appointed chief electrical engineer of Devenco Incorporated, New York, N. Y. Mr. McElwee was graduated from the University of Montana in 1919 with a bachelor of science degree and received his electrical engineering degree from that institution in 1925. He is a registered professional engineer in New York and Illinois. Mr. McElwee began his career with the General Electric Company and then worked for the Commonwealth Edison Company of Chicago, Ill., and the former United Electric Light and Power Company of New York. From 1929 to 1947, Mr. McElwee was assistant electrical superintendent of the State Line power plant of the Chicago District Electric Generating Corporation. From 1947 until he joined Devenco, he was second in charge of electrical design for the Kellex Corporation.

Leo Roy (M '46), head of Transmission and Distribution Section, Quebec Hydro-Electric Commission, Montreal, Quebec, Canada, has been appointed chief engineer of auxiliary services. **D. M. Farnham** (M '42), assistant chief engineer, Design Division, has become chief engineer of the division. Mr. Farnham is a member of the AIEE Insulated Conductors Committee (1947–53). **H. W. Haberl** (AM '28, M '45), apparatus and protection engineer, has been promoted to assistant chief engineer of the Engineering Design Division. Mr. Haberl has served on the AIEE committees on Protective Devices (1941–47) and Sections (1948–49). **J. R. Hango** (AM '31, M '44), system planning department, has been named system planning engineer, and **Archie Benjamin** (AM '30, M '52), assistant distribution engineer, has been promoted to distribution engineer.

J. H. Blankenbuehler (AM '31, F '48), design engineer, Hobart Brothers Company, Troy, Ohio, has been elected vice-president of the Central of the American Welding Society for a 2-year term. Mr. Blankenbuehler was born in Elizabeth, Pa., and was graduated from Lehigh University with a degree of electrical engineer. He worked at the Westinghouse Electric Corporation in Pittsburgh, Pa., for 23 years, starting as an engineer, and was manager of Welding Apparatus Engineering at the time he left Westinghouse in 1946. Since then he has been working for Hobart Brothers Company as design engineer. Mr. Blankenbuehler is a member of Tau Beta Pi, American Ordnance Association, American Society for Metals, Ohio Society of Professional Engineers, and is a registered professional engineer. He has served on the following AIEE committees: Electric Welding (1931–43, 1949–53); and Air Transportation (1948–53).

B. E. Shackelford (M '42, F '49), director of the license department, RCA International Division, New York, N. Y.; **J. R. Ragazzini** (AM '33, M '50), professor of electrical engineering, Columbia University, New York, N. Y.; **C. A. Priest** (M '45), assistant to the general manager of the commercial and government equipment department, General Electric Company, Syracuse, N. Y.; and **A. W. Straiton** (M '44), professor of electrical engineering and director of the electrical engineering research laboratories, University of Texas, Austin, have been elected directors of the Institute of Radio Engineers. Mr. Shackelford was elected a director for the 1953–55 term; Mr. Ragazzini was elected regional director of Region 2 (North Central Atlantic) for 1952–53; Mr. Priest was elected regional director of Region 4 (East Central) for 1952–53; Mr. Straiton was elected regional director of Region 6 (Southern) for 1952–53.

P. H. Goodell (AM '40, M '46), chief engineer, Jensen Specialties, Inc., Detroit, Mich., has joined Catalytic Combustion Corporation, Detroit, as sales manager. Mr. Goodell also has been associated with the Trumbull Electric Department of the General Electric Company. Mr. Goodell is a fellow in the Illuminating Engineering Society, a registered electrical engineer, and a member of the National Society of Professional Engineers. He has served on the AIEE committees on Electric Heating (1947–53, Chairman 1951–53) and Industry Division (1951–53), and as liaison representative from the AIEE Electric Heating Committee on the Committee on Ovens and Furnaces of the National Fire Protection Association.

A. L. Thurman (AM '38, M '45), assistant to the vice-president, Aetna-Standard Engineering Company, Ellwood City, Pa., has been appointed manager of the Plastics and Rubber Machinery Division. He will direct the activities of his new position from the Warren, Ohio, plant. Mr. Thurman has been with Aetna-Standard since 1945 and was formerly a steel mill application engineer for General Electric. He holds degrees in both mechanical and electrical engineering from Oklahoma Agricultural and Mechanical College.

W. L. Ringland (AM '36, M '44), electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named chief engineer of the motor and generator section of the power department. Mr.

Ringland was graduated from Purdue University in 1935 with a degree in electrical engineering and joined Allis-Chalmers in the same year. After completing the company's graduate training course he was assigned to the section which he now serves in his new capacity.

J. F. Sellers (AM '34, F '49), engineer-in-charge, D-C Section, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed assistant chief engineer, motor and generator section. Mr. Sellers came to Allis-Chalmers in 1923, the same year in which he received his electrical engineering degree from Purdue University. He was an engineer in the d-c engineering group of the motor and generator section from 1924 to 1941 and engineer-in-charge from 1941 to his present appointment. Mr. Sellers is a registered professional engineer, and has served on the following Institute committees: Land Transportation (1947–48); and Rotating Machinery (1947–51).

C. O. Weilbaecher (AM '41), electrical engineer, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed engineer-in-charge of d-c design, motor and generator section. Mr. Weilbaecher joined Allis-Chalmers in 1940 after graduating as an electrical engineer from Tulane University. He has worked in design engineering capacities in the motor and generator section.

L. T. Rosenberg (AM '30, M '36), engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named engineer-in-charge of a-c design, motor and generator section. Mr. Rosenberg has been associated with Allis-Chalmers since his graduation in 1926 as an electrical engineer from the University of Michigan. He completed the company's graduate training course and has worked in the a-c design motor and generator section since 1927. He is a member of the Wisconsin Society of Professional Engineers. He has served on the AIEE Membership Committee (1940–42).

H. C. Crane (M '48), chief engineer, Turnbull Elevator Company, Ltd., Toronto, Ontario, Canada, has been appointed a director of the company. Mr. Crane was graduated from the University of Toronto in 1921 with a bachelor of applied science degree in electrical engineering. He was a member of the university's faculty from 1921 to 1924, when he joined Turnbull Elevator Company's engineering department. He was appointed chief engineer in 1929. He is a member of the Ontario Association of Professional Engineers and a past president of the Engineers' Club of Toronto.

C. H. Bunch (AM '16, M '32, Member for Life), president, Acme Electric Corporation, Cuba, N. Y., has been advanced to chairman of the board of the company. Mr. Bunch, who helped to found the company in 1917, has held the office of president since 1942. Prior to becoming president, he held various other offices in turn from engineer, treasurer, to sales director. **J. A. Comstock** (AM '41), executive vice-president of the company, has been elected president. He joined the company in 1930 as chief engineer, having previously been transformer engineer with Modern Electric Company, Toledo, Ohio. He has been executive vice-president since 1946. Mr. Comstock is a member of the Illuminating Engineering Society.

L. E. Krauss (AM '51), assistant to the field engineer and industrial control estimator, Square D Company, Los Angeles, Calif., has been named Los Angeles field engineer for the company. A graduate of the University of Arizona, Mr. Krauss has been with Square D since 1950. He is a member of Tau Beta Pi.

J. R. Cobb (AM '45), manager, Farm Market Sales, Frigidaire Division, General Motors Corporation, Dayton, Ohio, has been appointed manager of the company's home laundry sales. Mr. Cobb, who was assistant chief of the Application and Loans Division, Rural Electrification Administration, became associated with the company in 1948.

L. R. Kahn (AM '51), project engineer, Crosby Laboratories, Inc., Mineola, N. Y., has opened a communications and electronics consulting office in Freeport, N. Y. Mr. Kahn attended the Polytechnic Institute of Brooklyn and is a member of the Institute of Radio Engineers, Tau Beta Pi, and Eta Kappa Nu.

R. A. Schatzel (AM '28), vice-president and director of engineering and research, Rome Cable Corporation, Rome, N. Y., has been elected a director of the company. Mr. Schatzel, an engineering graduate of Union College, has been connected with the electrical wire industry for the past 28 years. He has served on the AIEE Insulated Conductors Committee (1947–52).

J. B. Cataldo (AM '44), director of electrical research, John B. Pierce Foundation, Raritan, N. J., has been named director of research and development, BullDog Electric Products Company, Detroit, Mich. Mr. Cataldo was graduated from Newark (N.J.) College of Engineering in 1936. He is a member of Tau Beta Pi, the International Association of Electrical Inspectors, and the American Institute of Physics.

J. G. Derse (AM '41), sales representative, The Okonite Company, New York, N. Y, has been appointed manager, Utility and Industrial Sales, for the New York district territory. Mr. Derse has been a member of the sales department since 1929.

W. M. Terry, Jr. (AM '48), engineering department, Allis-Chalmers Manufacturing Company, Pittsburgh, Pa., has been appointed assistant chief engineer at the Pittsburgh Works. Mr. Terry was graduated from the University of New Mexico in 1946 with a bachelor of science degree in electrical engineering and joined Allis-Chalmers in 1947 as a development engineer.

D. J. Stewart (AM '25, M '48), vice-president and general manager, Barber-Colman Company, Rockford, Ill., and **L. W. Whitton** (AM '40), vice-president, Otis Elevator Company, New York, N. Y., have been named trustees of the recently formed Council for Technological Advancement.

N. J. Conrad (AM '07, F '21, Member for Life), president, S&C Electric Company, Chicago, Ill., has been elected chairman of the board of the company. A cofounder of the firm in 1910, Mr. Conrad has served as president since reacquiring control in 1945 from Cutler-Hammer, Inc., which had operated S&C between 1930 and 1945.

J. W. Allen (M '41), chief electrical engineer, Eclipse-Pioneer Division, Bendix Aviation Corporation, Teterboro, N. J., has been named chief engineer, electrical accessories division. Mr. Allen has served on the AIEE committees on Air Transportation (1944–54) and Standards (1946–53).

OBITUARY • • • • • •

Samuel Everett Doane, (AM '89, M '95, F '12, Member for Life), former General Electric Company Lamp Division executive, died December 9, 1952. Mr. Doane was chief engineer of the Lamp Division, Nela Park, Cleveland, Ohio, for many years. Mr. Doane was born in Swampscott, Mass., February 28, 1870. In 1886 after graduation from high school, he became a clerk for the Thompson-Houston Company, Lynn, Mass., where for 6 years he was tutored in mathematics and electrical engineering by Elihu Thompson. He joined General Electric in 1892 as assistant engineer of the Harrison (N. J.) Lamp Works. In 1897 he became superintendent of the Bryan-Marsh Company at Marlboro, Mass., and in 1901 was named chief engineer for the National Electric Lamp Association, for which Nela Park was named, in Cleveland. He retained this title when the association became

Samuel Everett Doane

the National Lamp Works of the General Electric Company. Under his leadership the Engineering Department and Lighting Institute at Nela Park achieved international prestige. During the 1920's, Mr. Doane devoted much of his time to consultation with foreign organizations in the lighting field. He retired in 1930. Mr. Doane was a member of The American Society of Mechanical Engineers, the Franklin Institute, the Ohio Electric Light Association, and the Electric League of Cleveland. In 1927 he received an honorary degree in electrical engineering from Case Institute of Technology.

Earl George Ports (AM '26, M '34, F '46) assistant technical director, Federal Telecommunication Laboratories, Inc., Nutley, N. J., died on December 4, 1952. Mr. Ports was born in Hanover, Pa., August 14, 1901. A graduate of Gettysburg College, he received his bachelor of science degree in electrical engineering in 1923 and his master of science degree in physics in 1925 while an instructor at Gettysburg. He was on the engineering staff of the Bell Telephone Laboratories until 1929 when he joined the International Telephone and Telegraph Corporation as an engineer with the International Communication Laboratories. In 1932 he became a transmitter engineer with the Federal Telegraph Company, Newark, N. J., a predecessor of Federal Telephone and Radio Corporation. Mr. Ports was appointed chief engineer in 1934 and served in that capacity until 1942 when he became manager of the Communication Product Division of the Federal Telephone and Radio Corporation. While with that company, he held the positions of technical director, assistant vice-president, and chief engineer and assistant manager of the Radio Division. In 1951, Mr. Ports became an assistant technical director of Federal Telecommunication Laboratories, Inc. Mr. Ports received the Navy Department's Certificate of Commendation in 1947. He was a member of the Institute of Radio Engineers. Mr. Ports was an active member of the AIEE, having served on the following Institute committees: Air Transportation (1945–47); Communication (1947–49); Aural Broadcasting Systems (1949–50, Chairman 1949–50); Standards (1949–50); Technical Program (1949–50); Communication Co-ordinating (1949–50); and Television and Aural Broadcasting Systems (1950–52).

Henry Ackley Lardner (AM '94, M '99, F '13, Member for Life), retired, the J. G. White Engineering Corporation, New York, N. Y., died December 27, 1952. Mr. Lardner was born in Oconomowoc, Wis., October 1, 1871. He received his bachelor of science degree in electrical engineering from the University of Wisconsin in 1893 and his master's degree from the same university in 1895, a year after he had joined the J. G. White Engineering Corporation. He took a leave of absence to teach at Pennsylvania State College from 1895 to 1897. In 1909 he became general manager of the corporation's San Francisco office and in 1913 became vice-president, which position he held until his retirement in 1950. Mr. Lardner had been mayor of Montclair, N. J., from 1924 to 1930. He was a former president of the Montclair Society of Engineers and a member of The American Society of Mechanical Engineers. A very active member of the AIEE, Mr. Lardner had served on the following committees: Public Policy (1914–16); Board of Trustees, United Engineering Societies (1921–25); Standards (1922–23); Education (1942–43); and Construction Industry Advisory Council Representative (1947–51).

William Jefferis Lank (AM '37, M '42, F '47), chief electrical engineer, Potomac Electric Power Company, Washington, D. C., died November 16, 1952. Mr. Lank was born November 6, 1903 in Wilmington, Del., and received his bachelor's degree in electrical engineering from the University of Delaware in 1925. Starting with the Potomac Electric Power Company as an electrical draftsman in 1925, he became system development engineer in 1937, system planning engineer in 1941, assistant to the executive vice-president in 1947, and chief electrical engineer later in 1947. He was widely known in the utility industry for his design of the 4-kv primary network system used extensively by the Potomac Electric Power Company. He had been very active in the Washington Section of the AIEE, having been at different times a member of the executive committee and the secretary-treasurer. He was a member of the Edison Electric Institute Electrical Equipment Committee and had served on the AIEE Substations Committee (1947–50).

James Steele Mahan (AM '12, M '24, F '27, Member for Life), consultant, Chicago, Ill., died October 19, 1952. Mr. Mahan was born in Memphis, Tenn., July 29, 1884. In 1903 he became an apprentice at the General Electric Company plant at West Lynn, Mass. He returned to Memphis in 1905 as assistant electrical inspector for the Memphis Insurance Exchange. In 1907 he became chief electrical inspector and in 1910 became chief electrical inspector of the city of Memphis. He transferred to the Western Actuarial Bureau in 1924 and in 1930 he became field engineer for Steel and Tubes, Inc. He opened his office in Chicago in 1934, specializing in electrical inspection activities. More recently he was affiliated with Bussman Manufacturing Company and Briegel Method Tool Company. He served on many committees of the Western Association of Electrical Inspectors and had been president of that organization.

Richard F. Pulver (M '46), vice-president and general sales manager, Minnesota Power and Light Company, Duluth, died November 8, 1952. Mr. Pulver was born in Kasota, Minn., June 8, 1899, and attended Gustavus Adolphus College and the University of Minnesota, receiving his bachelor of science degree in electrical engineering from the latter institution in 1923. Following his graduation, he was affiliated with the Northwest Paper Company, Cloquet, Minn., for a year, joining Minnesota Power and Light in 1924 as a power sales engineer. In 1936 he was promoted to industrial sales manager and continued in that capacity until December 1941 when he was appointed general sales manager. In May 1944 he was elected a vice-president of the company. Mr. Pulver was a past president of the North Central Electric Association and chairman of the North Central Electrical Industries.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of December 28, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Bergdahl, C. R., superintendent of public works, General Electric Co., Richland, Wash.
Dickson, R. C., chief electrician, Phelps Dodge Refining Corp., El Paso, Tex.
Farkas, E. C., design engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Fisk, D. B., asst. division engineer, General Electric Co., West Lynn, Mass.
Flachbarth, C. T., engineer, Walker Bros. Co., Conshohocken, Pa.
Folger, S. R., central station engg., General Electric Co., Philadelphia, Pa.
Gerber, J. H., application engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Greiner, A. C., headquarters application engineer, Square D Co., Milwaukee, Wis.
Hildebrand, W. F., sales engineer, General Electric Co., Tulsa, Okla.
Kirk, H., zone superintendent of power, Public Service Co. of Northern Illinois, Joliet, Ill.
Langhus, L., general plant superintendent, Central Electric & Gas Co., Lincoln, Nebr.
Martinez, J. B., vice-pres. & chief estimator, Reynolds Electrical & Engineering Co., El Paso, Tex.
McShea, W. T., Jr., electrical engineer, Ebasco Services, Inc., New York, N. Y.
Miller, R. C., product engg. supervisor, Sylvania Electric Products, Inc., Burlington, Iowa
Milton, O., section supervisor, Sandia Corporation, Albuquerque, N. Mex.
Nankervis, B. J., asst. electrical superintendent, Dow Chemical Co., Freeport, Tex.
Neubauer, W. H., superintendent, Amarillo Div., Southwestern Public Service Co., Amarillo, Tex.
Page, J. H., manager, Hydro Electric Commission, Renfrew, Ontario, Canada
Rutledge, O. C., manager, large motor & generator dept., General Electric Co., Schenectady, N. Y.
Turner, W. C., senior engineer, Alabama Power Co., Birmingham, Ala.
Vollum, E. O., electrical engg. associate, Water & Power Dept., City of Los Angeles, Calif.
Weiss, D., superintendent, relay dept., New Jersey Central Power & Light Co., Allenhurst, N. J.
White, K. E., manager, electrical laboratory, International Business Machines Corp., Endicott, N. Y.
Wolf, A. J., consulting engineer, George Wagschal Associates, Detroit, Mich.

24 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before February 25, 1953, or April 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Abbott-Smith, H. B., The Shawinigan Water & Power Co., Montreal, Quebec, Canada
Blair, N. M., Panellit, Inc., Chicago, Ill.
Franklin, P. J., National Bureau of Standards, Washington, D. C.
Friend, W. F., Ebasco Services Inc., New York, N. Y.
Gatis, G. E., Administracao do Porto do Recife, Pernambuco, Brazil South America
Gibbs, W. E., South Eastern Electricity Board, Hove, Sussex, England
Kiebert, M. V., Jr., Bendix Aviation Corp., Teterboro, N. J.
Kimball, R. D., c/o Richard D. Kimball Co., Boston, Mass.
Murphy, O. J., Bell Telephone Labs. Inc., New York, N. Y.

9 to grade of Member

Research Camera Designed for Study of Self-Luminous Transient Events

Based on the action of a mirror which rotates at a speed of 50,000 rpm and wipes an image onto film at a sweep rate of 5.466 millimeters per microsecond, a new research camera has been developed by Beckman and Whitley, Inc.

Belonging to the general classification often referred to as "smear" or "streak" cameras, this instrument is designed for the study of self-luminous transient events such as explosive, flash tube, and spark-discharge phenomena.

Appearance of the new unit is shown in Figure 2. The event to be studied is oriented before the vertical slit visible at the upper left and the photographic record is obtained on a 4- by 5-inch film located in the film holder between the operator's hands. A 4- by 10-inch film holder can be used on modified units. The high-speed rotating mirror is located inside the upper right section of the housing below the vertically projecting knob which can be seen in the illustration. This knob secures a vacuum-tight round access panel through which the mirror is rotated preliminary to a photographic run.

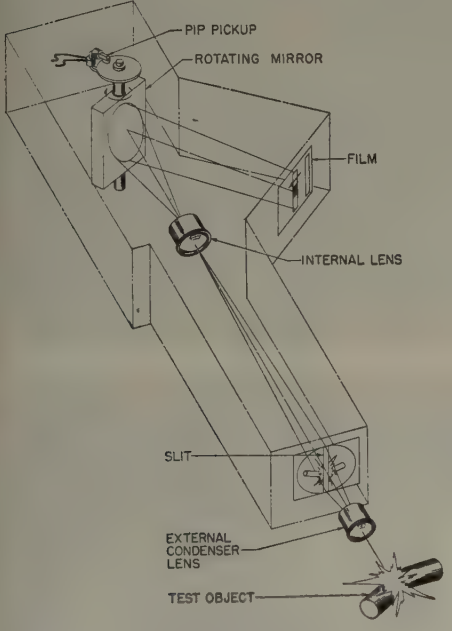


Figure 1. Mechanical schematic view of camera housing

A mechanical schematic view of the camera housing is shown in Figure 1. The self-luminous image of the test object is projected through the slit by an external condenser lens which is not part of the instrument. The internal lens forms an inverted nonmagnified image of the slit in the film plane after reflection from the mirror surface whose rotation sweeps the image across the film surface at a selected sweep rate in the direction shown. Any sweep rate may be chosen between 0.327 and 5.466 millimeters per microsecond. Thus the sequence of events at the test object which takes place in the vertical area imaged in the slit is separated in time as it is spread across the film.

Normal photographs of the test object can be taken in such a way that an image of the slit can be superimposed as a reference to show the section of the object which will be photographed during the test. Due to the high speed of operation, the mirror must be rotated in a vacuum and the camera housing is so designed—being equipped with a mechanical vacuum pump located in the lower portion of the stand. An air valve for releasing vacuum on the camera housing is located at the right of the horizontal working surface of the unit.

Included in the lower cabinet are the electromechanical mirror drive and electrical component panel, a return air filter, and lubricating-oil supplies for the camera drive. Located on the horizontal control panel at the left of the unit is a shutter button to control the various exposures described. A further control permits the operator to scan the entire test object by slowly moving the shutter opening across the image. Focusing is accomplished on a ground plastic surface at the film holder using the 6-times focusing magnifier visible in Figure 2.

Synchronizing of the exposure with actuation of the test object is accomplished through the pip-generating commutator seen on top of the mirror in Figure 1. Each turn of the mirror produces a 15-volt minimum pulse which is used to trigger and synchronize the test object so that the image will be positioned on the film.

The slit plate is formed from a piece of flat glass having an opaque coating on one side through which the slit line has been ruled. This plate is movable sideways on precise guides for the taking of conventional photographs. Slit width is 0.010 inch.

The shutter is a high-speed guillotine type designed to prevent multiple exposure when phenomena of long duration are being observed. Operable by external electric impulse, the shutter can be used also to actuate related equipment. Exposure time is 1/200 second.

Lenses are color corrected for the 4,500-angstrom-unit region, coated, and have resolving power of 30 lines per millimeter.

The mirror, of high-quality stainless steel, has a working surface optically flat to one circular fringe and is rotatable at continuously adjustable speeds ranging from 3,000 to 50,000 rpm.

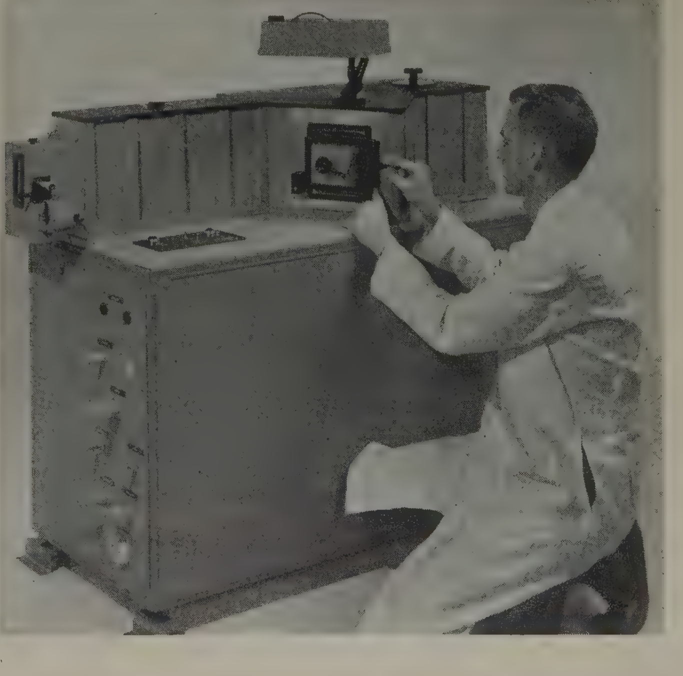


Figure 2. External appearance of new research camera

Future Meetings of Other Societies

American Society of Tool Engineers. 21st Annual Meeting. March 17–20, 1953, Hotel Statler, Detroit, Mich.

Institute of Radio Engineers. Southwestern Conference and Electronics Show. February 5–7, 1953, Plaza Hotel, San Antonio, Tex.

Institution of Electrical Engineers. Symposium on Insulating Materials. March 16–18, 1953, Institution Building, London, England

National Association of Corrosion Engineers. 5-day, Short Course in Corrosion. February 2–6, 1953, University of California, Berkeley, Calif.

National Association of Corrosion Engineers. 9th Annual Meeting. March 16–20, 1953, Hotel Sherman, Chicago, Ill.

National Electrical Manufacturers Association. March 9–12, 1953, Edgewater Beach Hotel, Chicago, Ill.

Protective Relay Engineers. 6th Annual Conference. March 23–25, 1953, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Tex.

Society of the Plastics Industry. 8th Annual Reinforced Plastics Division Conference. February 18–20, 1953, Shoreham Hotel, Washington, D. C.

Hot Laboratory Helps Solve Problems of Work With Radioactive Materials

Nuclear scientists, who work daily with radioactive materials too "hot" to handle, have been able to solve many of their problems by using one of the most unique tools of the Atomic Age—the "Hot Laboratory."

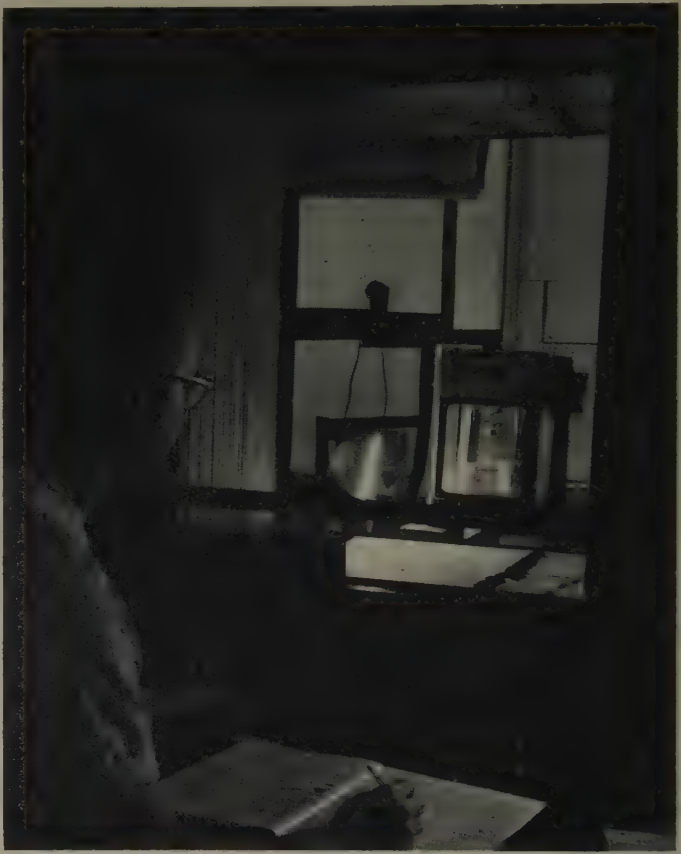
One such group of scientists is at work in the Bettis Plant, Pittsburgh, Pa., of the United States Atomic Energy Commission. This plant is operated by the Westinghouse Atomic Power Division, which is engaged in two of the nation's atomic projects. These are the construction of the atomic power plant for the submarine, *U. S. S. Nautilus*, and development of another nuclear reactor for a large vessel, such as an aircraft carrier. Both projects are being conducted for the United States Navy and the Atomic Energy Commission.

A major problem in the construction of nuclear reactors is that of handling radioactive materials during tests and laboratory analyses. For safety purposes, this testing is done almost completely by remote control in a building known as the "hot lab."

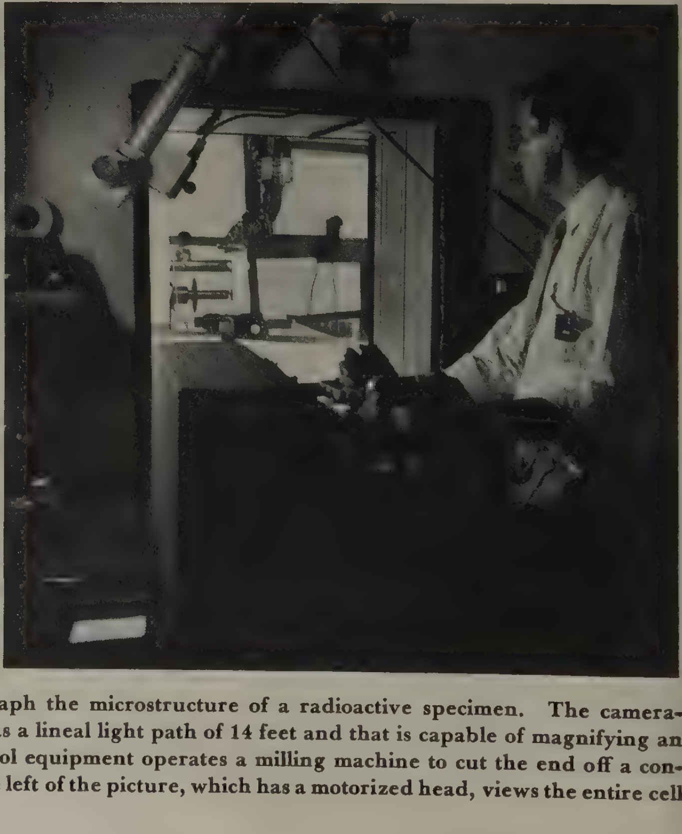
There are five "hot spots," or cells, in the Westinghouse hot lab and these are separated from the main working area by a thick concrete and lead wall. In the cells themselves, which are each separated from the other by a thick steel wall, are testing devices designed especially for the laboratory's operation.

The inside of each cell is viewed through a 36-inch-thick window comprised of layers of plate glass separated by oil. Mechanical, clawlike "hands," which are controlled from outside the cell, move radioactive objects into position for testing. A periscope-telescope arrangement enables scientists to examine specimens in the laboratory through a remotely controlled microscope.

Remote control equipment operates a milling machine in one of the cells to cut the end off a container holding radioactive material to be tested. Once the end of the specimen container is removed, the untouchable objects are dropped into a tray, picked up by another, but smaller, manipulator and carried to another cell to test physical and mechanical properties.



The device behind the thick glass-oil window is called a "Gram-atic Balance" and is so sensitive that it is capable of weighing the amount of lead used to write the word "Gramatic," or 11-millionths of a pound. Technician is weighing a specimen which has been subjected to radiation to find out how much of a weight change has taken place



(Left) Technician operates a specially designed camera to photograph the microstructure of a radioactive specimen. The camera-periscope arrangement is linked to a high-power microscrope that has a lineal light path of 14 feet and that is capable of magnifying an object in its field 2,000 times. (Right) Engineer using remote control equipment operates a milling machine to cut the end off a container holding radioactive material to be tested. The periscope at the left of the picture, which has a motorized head, views the entire cell

Other cells in the hot laboratory are used for weighing specimens which have been subjected to radiation to find out how much of a weight change has taken place, for finding out how much of an impact a material will stand after it has been exposed to radiation, for photographing the microstructure of a radioactive specimen to determine if any change has taken place as a result of exposure to radiation, and for determining how radioactivity affects the hardness of a material. (See cover picture.)

All the operations, including changing of focus, lenses, and specimen in photography, and focusing and lens changing on the microscopes, are done by remote control.

$250,000 2-Way Radio-Telephone Network Established for Montana-Dakota Utilities

The Montana-Dakota Utilities Company (MDU) has established a $250,000 radio-telephone network to improve customer service and increase the operating efficiency of its electric power and gas systems in North and South Dakota, Montana, and Wyoming. Engineers of the General Electric Company, who assisted in planning the network, said it is one of the largest of its kind in the nation.

Radio equipment includes 26 fixed transmitting stations, 45 remote control units for these stations, and 150 mobile radio-telephones. Seven more transmitting stations will be installed when license applications filed with the Federal Communications Commission are approved.

In a report to General Electric, R. M. Heskett, president of MDU, said: "Many of the interruptions in our electrical and gas service are caused by severe winter storms in the areas we serve. These storms also frequently cripple wire-line communication facilities formerly needed for repair operations. The new radio network will aid our repair crews in any emergency and will speed repair work when normal means of communication are insufficient or disrupted by weather conditions. Radio is relatively unaffected by bad weather.

"The radio network will also be available to help public relief crews during severe storms, floods, and other catastrophes which result in disrupted communication facilities. The entire network also would be made available to civil defense authorities in a wartime emergency."

Because radio will provide fast communications between repair crews in the field and power and gas headquarters plants, customers will have their service resumed quicker when outages are caused by natural or man-made forces, the utility president said.

In remote areas it was previously necessary for field crews to drive to the nearest telephone to contact headquarters. This often consumed much time and travel before repairs could be started, a delay now remedied by radio, he explained.

"During one storm, for example, both power and telephone lines were down in one area. It was necessary to hire an airplane to fly to a power generating plant with instructions to kill the power in the area while repairs were made. With radio, the message could have been delivered directly and instantly from the damaged area."

The company's vast electric systems distribute power from seven of its own electric generating plants, in addition to the Fort Peck hydroelectric plant operated by the United States Government. The proposed government hydroelectric plant at Garrison, N. Dak., will also supply power to the MDU system, when it is completed.

There are at present 2,850 miles of electric power transmission line and 1,400 miles of gas pipe line in the company's systems, serving 64,000 electric and 65,000 gas customers.

The fixed radio transmitting stations are located on high points of land where possible, with remote control units located in the company's offices or power plants. Company officials can talk directly from their offices to radio-equipped service vehicles 30 to 100 miles from the transmitter site, depending on the terrain between. The radio network operates on very-high frequencies, and therefore is essentially limited to line-of-sight reception.

To permit conversations between offices throughout the sprawling electric and gas systems, a number of fixed transmitting stations serve as automatic repeater stations. Calls from one office to another beyond direct reception range are picked up and rebroadcast by the repeater stations until they can be received by the desired office.

One vehicle may call another directly, but the rough terrain often prohibits reception over great distances. By calling via a repeater station, however, vehicles can reach each other, or their office, over much greater distances. The repeater stations normally are on the highest possible land in the area.

There are six main radio dispatching headquarters in the company's network, to which respective groups of the 150 mobile radio-telephone equipped vehicles report. They are the company's divisional offices at Bismarck, Mobridge, and Williston, N. Dak.; Glendive and Great Falls, Mont.; and Worland, Wyo.

Conversations can be relayed automatically, or by station personnel, between all of these main dispatching points except Great Falls. This station is too far from the rest of the network to be tied into it.

The Great Falls transmitting station can be operated from any one of three remote control points in the area. It controls the activities of more than 30 radio-equipped vehicles serving the Cut Bank, Kevin-Sunburst, Whitlash, and Utopia gas fields, and gas consumers in the area.

In the Bismarck area, there are 25 radio-equipped vehicles serving 13,713 electric and 6,238 gas customers in that area. More radio-telephone equipment will be installed in the Bismarck area in the near future.

Twenty vehicles in the Mobridge area are radio-equipped, with 40 in the Glendive area, 21 at Williston, and 10 in Worland. In addition to the radio-telephones installed in vehicles, the company has 20 walkie-talkie-type units which permit men on foot, or snowshoes, to maintain contact with radio-equipped vehicles a mile or two away.

One use made of the walkie-talkie radios is to maintain instant contact between

Two-way radio in line truck being used while workmen repair wire lines in background

Pipe-line construction supervisor uses 2-way radio in truck to call divisional offices for additional equipment on gas feeder line under construction

airplanes flying patrol over gas pipe lines, and company offices or compressors stations. Airplanes are frequently used to locate leaks in pipe lines.

The company uses snowmobiles and other special vehicles to transport repair crews in the winter months. When they are used, radio-telephones are transferred to them from regular vehicles not used during the winter.

Coaxial Cable System Handles Both Telephone and TV Signals

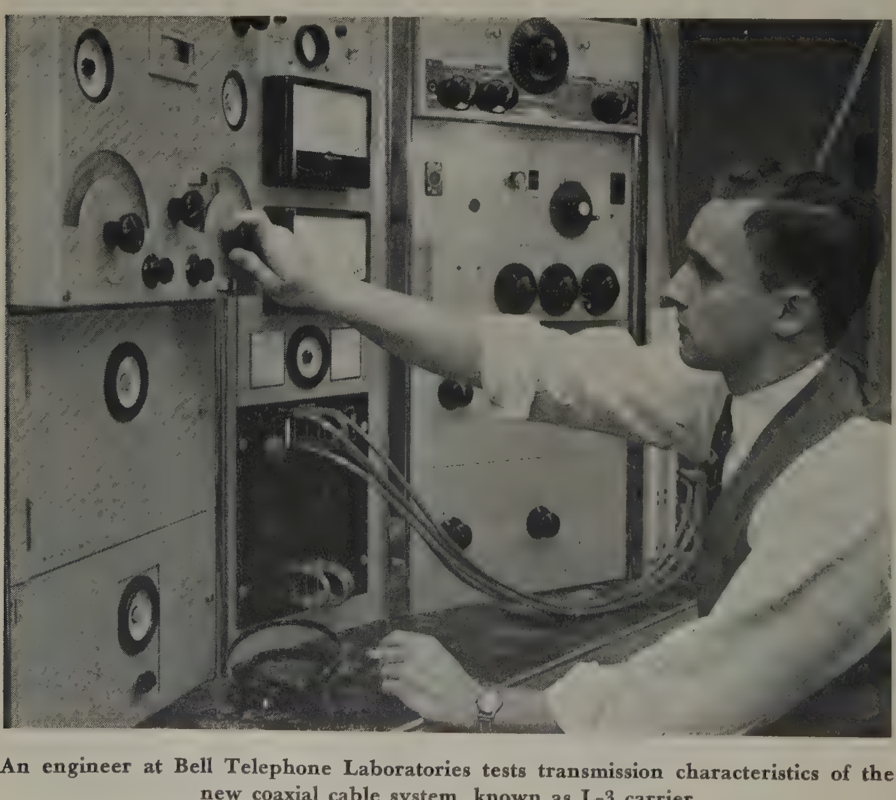
A revolutionary new coaxial cable system, with triple the telephone circuit capacity of those now in use, has been developed by Bell Telephone Laboratories and is undergoing exhaustive field trials prior to its installation for use in the Bell System. It is expected to go into actual service on circuits between New York, N. Y., and Philadelphia, Pa., early in 1953.

The new system, known as L-3 carrier, will enable one pair of coaxial pipes (pencil-size tubes of copper within the cable itself) to handle simultaneously more than 1,800 telephone conversations or 600 telephone conversations plus one television program in each direction. It will be the first carrier system on which both television signals and regular telephone conversations can be sent over the same pair of coaxial pipes at the same time.

Bell Laboratories, in designing L-3, has brought numerous advances to bear upon transmission technology. It was necessary, for example, to design new amplifiers or "repeaters," with characteristics exceeding any earlier type. In L-3, as in earlier coaxial systems, power is fed to the repeaters over the coaxial cable from widely separated power points. The higher power requirements of the new repeaters—and the fact that twice as many are used in the new system—presented a number of technical problems.

New terminal equipment also was necessary to pile up 1,800 circuits and permit both addition and subtraction of smaller groups of circuits at intermediate points. Means for putting television signals on the line and distributing them at intermediate points without introducing distortion had to be developed. Sending both television and telephone signals over the same circuits created the problem of preventing interference between the two types of signals.

Coaxial cable is one of the two types of facilities used by the Bell System in its intercity television networks. The other type is radio relay, an entirely different method of transmitting communication services. Although coaxial cable and radio relay systems are constructed primarily to meet the needs of long-distance telephone service, provision is being made at the same time for television channels and other Bell System communication services where demand warrants it.



An engineer at Bell Telephone Laboratories tests transmission characteristics of the new coaxial cable system, known as L-3 carrier

1,218-Foot Radio Tower Provides Electronic Data for Air Force

One of the highest man-made structures in the world stretches into the sky in upstate New York to provide Air Research and Development Command scientists with data required to improve constantly the United States Air Force's utilization of radio.

This structure is a 1,218-foot radio tower located at Forestport, N. Y., and is utilized by the Rome Air Development Center (RADC) at Griffiss Air Force Base, N. Y. At this Center, one of nine under the Air Research and Development Command, the Air Force concentrates its development work in the field of electronics. Beaming experimental radio waves over a large expanse of the universe, the tower fills an urgent electronics development requirement for the nation. The tower required 772 tons of fabricated steel and is supported by 4 miles of guy cables, some of which are anchored almost 1/4 mile from the tower's base.

The tower is a vertical antenna of open framework, a guyed steel structure, shaped as an equilateral triangle whose sides are spaced 15 feet from center to center of the leg members. The tower's foundation rests on crystalline sand derived from wastage of quartz rose rocks with morine deposits beneath.

Construction of the RADC tower hinged on one major problem. Guy cables had to be of sufficient strength to withstand wind pressure which the structure might encounter from time to time, in addition to dead weight of the structure and ice coating during winter months. Galvanized bridge rope solved the problem as guys.

The RADC tower is a guyed-steel structure, with a tapered base section that converges at the base casting and provides a single pivot support. The antenna is guyed at three levels with galvanized bridge rope.

The top and intermediate guys have the same vertical plane, as well as a common ground anchorage, at a radius of 1,051 feet from the vertical center of the antenna. Each lower guy forms a set of three with a single anchorage at a radius of 525.5 feet from the vertical center of the antenna. Each set of guys radiates at an angle of 60 degrees from each of the tower's triangle legs.

An electrically controlled elevator, used in maintenance and inspection, carries a 700-pound load at the rate of 70 feet per minute.

At each elevation of obstruction lights, there are six sets attached at 120-foot intervals to the tower as specified in Civil Aeronautics Authority regulations, and there is a maintenance platform, with entry and exit made from the elevator cab. A telephone is placed at the entrance of the elevator on each platform. These are sound-power telephones which can be heard simultaneously at all levels.

Many obstacles were overcome during the 75 working days used to erect the Rome Air Development Tower. Near completion of the tower, winds were recorded at 120 miles per hour and gave the tower its first test. The sway was less than half the 7 feet the tower is calculated to take in a 150-mile-per-hour gale. Often, men working at the top of the tower, 1/4 mile above ground, worked in the sun while a heavy fog blanketed the ground crew.

Foundation conditions for the mast were determined following a soil investigation performed under government supervision. The mast foundation supports 4,200 pounds per square foot, 1,800 under the limit determined by the investigation. The central pier, on which the main tower rests, is a pyramid mass of reinforced concrete. The guy anchors are of concrete and provide sufficient weight to overcome uplift.

Stability of the antenna structure depends largely upon proper erection and assembly

The 1,218-foot radio tower at Forestport, N. Y., before it was erected when materials for the tower were stored at the Rome Air Development Center. The tower, one of the highest man-made structures in the world, is used to provide data required to improve constantly the United States Air Force's utilization of radio

of the materials as well as careful and proper setting of the guys to their correct tension under the most favorable wind conditions and when there is no ice load on the tower and guys.

Below the bottom base pivot casting of the antenna is a dome-shaped steel casting. The dome-shaped antenna casting is provided at three contact points with three 400-ton hydraulic jacks which may facilitate a change of the base insulator elements.

The tower and its supporting guy cables press down a weight of 2,280,077 pounds on a single pivot casting, mounted on three porcelain insulator elements.

The height of the guy attachments and the location of the ground guy anchors are proportioned to reduce to a reasonable minimum reverse flexure in the antenna structure produced by wind loads. This, combined with unequal distances between guy attachments and the base structure, reduces to a reasonable minimum any tendency toward dynamic stresses and the accumulation of axial stresses. The guy ropes are provided with porcelain insulators at unequal spaces and at varying levels to counteract any tendency toward dynamic stresses in the guys.

The antenna is constructed principally of solid rounds or pipe columns, while the horizontal struts are paired angles. The cross braces, except at guy levels, are steel rods with turnbuckles and pin connections.

The porcelain insulator assemblies and dome casting consist of three triangular-spaced cone-shaped porcelain elements pretested to a compression of 290,000 pounds per square inch. The large end is cemented into a casting on the central foundation base plate. The small ends are cemented into a cap bearing casting. The three cap castings provide bearing points for a dome-shaped spider dome.

Radiant Heating Panel Uses Electrically Conductive Rubber

An electric radiant heating panel only 1/16 of an inch thick which can be cemented to the ceiling like wallpaper has been developed by United States Rubber Company. The new panel, called Uskon, is a sheet of conductive rubber that is the heating unit, sandwiched between layers of thin plastic and aluminum foil.

Complete radiant heating for an entire house or for a single room is possible with the panels. They are particularly useful for homeowners who add a new room or who want to supplement existing heat in such places as a den, expansion attic, or garage.

The panels are extremely light, weighing only 6 ounces per square foot. They are bonded to ceilings of plaster, sheetrock, or similar smooth material by means of a special adhesive. Occasionally, molding is used in conjunction with the adhesive. The number of panels required is determined by climate, insulation, and other factors, but generally, Uskon does not cover the entire ceiling.

Where electricity is available for $1^1/_2$¢ a kilowatt-hour or less, the cost of operation is comparable with that of other fuels.

Three sizes of panels are available, 4 by 6 feet, 4 by 4 feet, and 3 by 4 feet, and both outer surfaces are covered with aluminum foil to keep out moisture. The panels are rated at 22 watts per square foot (75 Btu's) and are available for either 115 or 230 volts. Due to the absence of abnormally high temperatures at concentrated points, hazards from burns and scorchings are eliminated.

Use of Uskon heating panels provides more living space in homes because there are no radiators, wall heaters, chimneys, furnaces, boilers, ducts, or valves.

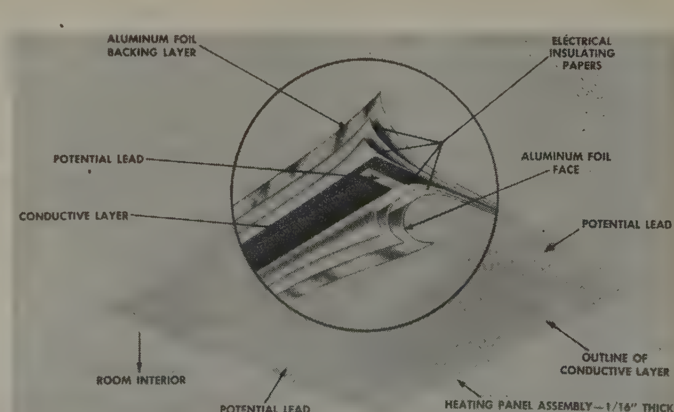
Scientific analysis has indicated that radiant heat in the ceiling is comfortable and healthful because of its uniformity and freedom from drafts, and because it is the nearest approach to the natural heat of the sun. Surface temperature of the ceiling panels averages about 100 degrees, and the heat rays warm the floor and other objects in the room without heating the air.

Excessively dry air is avoided, and the humidity approaches that of the outdoors. There is no fuel soot, no fumes, and virtually no dust in circulation. Individual room heating may be operated by thermostatic control, if desired.

Panels can be attached to ceilings without any cutting, rebuilding, plastering, or structural changes. They are then painted with conventional flat interior decoration.

Full advantage of Uskon radiant panels cannot generally be realized in cold climates unless the structure is insulated. Insulation is always required in back of Uskon panel ceilings in single-story structures or top stories of multiple-story structures.

Uskon converts electric energy to heating energy with an efficiency of 100 per cent and utilizes the heat produced in its most efficient form, that of radiation. In many parts of the country the cost of heating with electricity is competitive with other fuels. In other areas the direct cost of heating with electricity is more expensive. However, the Uskon panels with their individual room control, quick response, low heat lag, uniform heat, and radiant effects permit substantial economies in the use of electric energy as fuel.



Construction diagram shows how Uskon panels are made of very thin sheets of conductive rubber between layers of thin plastic and aluminum foil. There are no heating wires in the panels

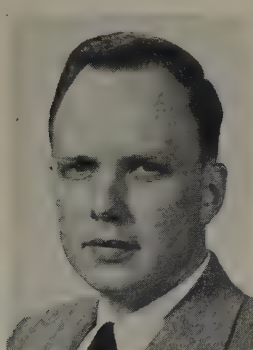
1952 Winners Announced for Eta Kappa Nu Awards

John Van Nuys Granger, director of the Stanford Research Institute's Aircraft Radiation Laboratory, Stanford, Calif., has been named winner of the Eta Kappa Nu Award for the Outstanding Young Electrical Engineer of 1952. Presentation of the awards to Dr. Granger and to the two Honorable Mention winners, Gustav W. Staats (AM '43) and Edward O. Johnson (AM '52), were made at a dinner held at the Henry Hudson Hotel in New York, N. Y., January 19, 1953.

Born in Marion, Iowa, on September 14, 1918, Dr. Granger majored in mathematics and physics at Cornell College in Iowa, and in 1941 attended the Harvard graduate school on a scholarship in communications engineering where he acquired a master of science degree. By 1942 he had become a Teaching Fellow in Physics and Communications Engineering, acting as an instructor in

The Eta Kappa Nu Jury of Awards selects the Outstanding Young Electrical Engineer for 1952. Left to right are C. B. Jolliffe, T. G. LeClair, T. C. Fry, Robin Beach, E. A. Walker, and E. B. Kurtz

the pre-radar school for Army and Navy officers, and then joined the Radio Research Laboratory at Harvard where he became a project engineer on ultrahigh-frequency search and intercept receivers. In 1944 he joined the American-British Laboratory at Great Malvern, England, and later transferred to France as civilian technical advisor to the Director of Communications, First Tactical Air Force (French-American). Dr. Granger received his doctorate from Harvard University in 1948, and when Stanford set up the Aircraft Radiation Systems Laboratory, he was placed in charge of the technical and administrative direction of the laboratory. Since 1950 Dr. Granger has been active as a civilian member of the Panel on Antennas and Propagation of the Committee on Electronics (Research and Development Board) and in 1951 he was elected chairman of the Subpanel on Airborne Antennas. He also is a member of the Institute of Radio Engineers, Commission VI of the United States National Committee of the International Scientific Radio Union, and was recently appointed assistant chairman of the Engineering Department of Stanford Research Institute. Biographical sketches of the two Honorable Mention winners appear in the AIEE Personalities section of this issue (*pages 174–5*).



J. V. N. Granger

Correction. In the report of the Electrical Insulation Conference on page 1156 of the December 1952 issue, it was stated erroneously that G. T. Kohman was the Vice-Chairman of the 1953 Conference. The Vice-Chairman for 1953 is D. A. McLean, Bell Telephone Laboratories.

Electron Linear Accelerator Unveiled by Stanford University

A 200-foot "rifle," designed to fire electron "bullets" at approximately the speed of light and to develop energies up to 1,000,000,000 volts, was unveiled recently by Stanford University as the newest tool for probing the nucleus of the atom.

It is the latest and the world's most powerful atom smasher of the linear accelerator type. That is, it shoots its beam of bombarding electrons in a straight line instead of in the circular path followed by the bullets of electrons, protons, or other particles employed in most types of atom smashers, such as cyclotrons, synchrotrons, or cosmotrons.

One use to which the linear accelerator may be put, it was suggested, was to see into an atomic nucleus. The laboratory experts hope to be able to discern spatial relationships of particles within the nucleus and to record events taking place within the atom only one one-hundred millionth of a second apart. Scientists still would like to know much more than they do about the spacing of neutrons and protons and what holds them together in the atomic nucleus.

When Stanford's accelerator is in full operation, its series of specially built vacuum tubes, described as the most powerful in the world, would put out about as much electric power in one-millionth of a second burst as the whole city of San Francisco requires during a similar period.

When it is in full operation, the velocities of its electron bullets will be the greatest ever obtained on earth, according to Stanford physicists. They put the potential speed at 99.9999 per cent of the speed of light, which travels at 186,278 miles an hour, the highest speed possible in the universe.

In its operation to date, the Stanford accelerator has produced up to 350,000,000 electron volts of energy, or about one-third of the maximum expected when an end station for the present microwave laboratory is completed.

Dr. Edward L. Ginzton, director of the laboratory, said, however, that in principle there was no limit to the energies a linear accelerator atom smasher could reach by adding to its length under suitable power conditions.

"One hopes," Dr. Ginzton said, "to make it more powerful than 1,000,000,000 volts eventually, but for the lifetime of this machine it will be operated at much lower velocities."

The accelerator operates in a manner similar to this: A jolt of electricity, 80,000 volts, pulls bunches of 100,000,000,000 electrons each from a glass cylinder serving as the firing chamber. Tungsten was selected as the chemical element to supply the electron bullets because of high melting point and long life. These electrons are propelled into the gun tube, $3^1/_2$ inches in diameter, at about one-half the speed of light. Within 2 feet their speed is almost doubled.

Twenty-one klystrons, the powerful vacuum tubes used in the apparatus, are stationed at 10-foot intervals along the gun tube. Each of them gives the electrons a terrific kick by means of ultrahigh-frequency radio waves on which the electronic beam rides.

Every foot of distance covered by the beam of bullets adds 4,500,000 volts of energy, which is converted into matter, giving every electron when it reaches the end of the tube a weight 2,000 times greater than it had when fired. When the bullet hits the target, the additional mass is reconverted to energy; which is used to break up the atomic target with its constituents.

National Registration Bureau Can Serve Professional Engineers

Registered professional engineers who require registration or license in several states will find that their applications for registration in states other than the one in which they are registered are expedited greatly and, in some cases, approved promptly when they have been certified by the National Bureau of Engineering Registration and endorsed by their State Board of Registration.

Although it is unconstitutional for any bureau to offer national registration and this bureau cannot legally register anyone in any state, this bureau can make a factual certification of an engineer's education, experience, and references. Such a certification may eliminate the necessity and imposition of requesting former employers, educational institutions, and friends to answer the same questions over and over again. It also establishes requirements in excess of the minimum under any state law.

Eighty per cent of the individual states report that they accept either wholly or in part the factual findings represented in a certificate granted by the National Bureau of Engineering Registration.

For a fee of $35 the National Bureau will pass on an applicant. At an additional cost of $2 each, photostatic copies of the engineer's completed and verified professional record may be obtained. If copies of the replies by the five references are required, the total cost is $5.

Although many engineers are now registered in more than one state, only a small per cent of such engineers have availed themselves of the assistance offered by this bureau.

An engineer seeking registration in

multiple states will find a National Certificate helpful in expediting his application for registration. Such engineers are urged to make use of the assistance of the National Bureau of Engineering Registration.

Electrochemistry Symposium to Be Held in New York City

The latest information on new techniques involving electrochemical principles as applied now by medical and biological scientists will be presented in a "Symposium on the Application of Electrochemistry to Biology and Medicine" at the Spring Meeting of The Electrochemical Society. The meeting will take place at the Statler Hotel, New York, N. Y., April 12–16, 1953.

This important symposium, under the general chairmanship of Dr. Detlev W. Bronk, president of Johns Hopkins University, Baltimore Md., has been arranged by the Theoretical Electrochemistry Division of the society. The scope of this symposium is indicated by the schedule which calls for six separate sessions in various fields.

Tentative titles of sessions are: general; electrochemical phenomena of nerve transmission and muscular reactions; electrochemical studies of proteins, blood, and plant cells; membrane potentials; electrokinetic phenomena in biology and medicine; and clinical applications.

A detailed program will be available late in February and may be obtained by writing to the office of The Electrochemical Society, 235 West 102d Street, New York 25, N. Y.

1953 IRE National Convention Set for March in New York City

More than 30,000 radio engineers and scientists from all parts of the world are expected for the 1953 Institute of Radio Engineers (IRE) National Convention to be held March 23–26 at the Waldorf-Astoria Hotel and Grand Central Palace in New York, N. Y. The comprehensive program of 220 technical papers and 400 engineering exhibits will be keynoted by the theme "Radio-Electronics, A Preview of Progress."

The 43-session technical program will be highlighted by an all-day seminar and 9 symposia organized by professional groups of the IRE. The seminar will be on "Acoustics for the Radio Engineer," and will comprise a tutorial discussion between a 6-member panel and the audience. The symposia will cover television broadcasting, ultrahigh frequencies, wide-band amplifiers, large-scale digital computers, engineering management, transistor measurements, manufacture of microwave equipment, nucleonics, and mobile communications.

The Grand Central Palace will be the scene of the display of radio-electronic apparatus and their applications. The Radio Engineering Show, comprising some 400 exhibits, will occupy all four floors of the Palace. For the convenience of visitors, many of the exhibits on the third and fourth floors will be grouped according to such subjects as audio, nuclear, components, instruments, mobile equipment, military radio, air-borne equipment, and computers. Several theaters will be provided for the demonstration of audio and television equipment.

Applications Invited for Study in Oak Ridge Reactor School

Applications are being received now for enrollment in the 1953–54 session of the Oak Ridge School of Reactor Technology which begins in September 1953. Students with graduate or undergraduate degrees in engineering or one of the basic sciences, or who will have attained such a degree by September 1953, and who have special interest and aptitude to engage in applied nuclear science and engineering, are invited to apply for admittance. Prospective students must be United States citizens and appointment to the school is contingent upon satisfactory completion of an Atomic Energy Commission security investigation prior to September 1953. Complete applications must be filed with the Oak Ridge School of Reactor Technology on or before March 1, 1953.

Further information and application forms may be obtained from the Oak Ridge School of Reactor Technology, P. O. Box P, Oak Ridge, Tenn.

Resistance Welder Manufacturers Announce Prize Paper Contest

Announcement has been made of cash prizes to be awarded in 1953 by the Resistance Welder Manufacturers' Association for outstanding papers dealing with resistance welding subjects. The total amount of the awards is $2,250, and a wide choice in subject matter is allowed in order to assure eligibility to all papers which cover worth-while and significant achievements in the field. The contest judges will be appointed by the American Welding Society and awards will be made at the 1953 fall meeting of the society.

For rules and further particulars write to Resistance Welder Manufacturers' Association, 1900 Arch Street, Philadelphia 3, Pa.

Engineering Curricula and Programs Accredited by ECPD

The work of accrediting undergraduate engineering curricula and the programs of the technical institute type in the United States has been continued by the Educational Committee of the Engineers' Council for Professional Development (ECPD). The work of accreditation has received wide acceptance by the schools, the profession, and the public.

As of September 5, 1952, ECPD had accredited some 730 engineering curricula representing 149 different schools with accredited curricula. Some 67 programs of the technical institute type have been accredited in 22 technical institutes.

The complete list of accredited undergraduate engineering curricula by institutions and by curricula, as well as the list of accredited programs of the technical institute type, has been made available by ECPD in a pamphlet with statements on the bases of accrediting. This list may be purchased at a price of 25¢ each. The annual report of the ECPD which includes the list of accredited curricula and institutions is available for 50¢ each. Please address all orders to the Secretary of ECPD, 29 West 39th Street, New York 18, N. Y., and include remittance with order.

Twentieth Annual Report on Activities Issued by ECPD

The Engineers' Council for Professional Development (ECPD) has issued its Twentieth Annual Report, covering activities in 1951–52. The following achievements of the past year are emphasized.

The development of activities for high school boys who are interested in entering engineering professions was a major project. It is the aim of the committee entrusted with this work to have an organization from which any boy in the United States and Canada, who is interested, can obtain sound information on such points as the academic demands on his ability, his prospects in the profession, the universities offering engineering curricula in his locality, and other pertinent facts. It is hoped that the work of this committee will do something to alleviate the present shortage of engineers without trying to induce unsuitable men to enter the profession.

The progress in the training program for young engineers is described in detail in the report of the Training Committee. Reports of other ECPD committees, representatives from member organizations, and lists of accredited engineering curricula and institutions are included.

Copies of the report are available at the price of 50¢ each from the Secretary of ECPD, 29 West 39th Street, New York 18, N. Y. Please include remittance with order.

Conference on Instrumentation to Be Held March 19–20, 1953

The Electrical Engineering Department of Michigan State College, in co-operation with the National Science Foundation, the National Bureau of Standards, the Instrument Society of America, and the American Society for Engineering Education, announces an invitational National Collegiate-Industry-Government Conference on Instrumentation to be held on its campus, March 19–20, 1953.

The conference is being called in recognition of the growing importance and potential of instrumentation in research and production and the national defense. The objectives of the conference are to relate the role and needs of instrumentation in production and research to college interests and responsibilities; to review current instrumentation activities in the colleges; to suggest specific activities the colleges might undertake in this field; and to suggest specific ways by which industry might assist the colleges in these activities.

Educational and industrial administrators, and others interested in the field of instru-

mentation who would like additional information concerning the conference, should write to Professor R. J. Jeffries, Department of Electrical Engineering, Michigan State College of Agriculture and Applied Science, East Lansing, Mich., at once, as attendance will be limited.

First Consumer Product Use of Transistors in Hearing Aid

First use of transistors in a product available to the general public has been announced by Sonotone Corporation with the introduction of a miniature transistor hearing aid which will give double the power of any comparable instrument at half the operating cost.

Initial fulfillment of the prospect of a miniaturized world, the new Sonotone "1010" is the thinnest and smallest, 3 ounces, hearing aid the company has made. It is only a little larger than a box of safety matches, can be worn invisibly by women, inconspicuously by men.

The new hearing aid has three power units, the transistor, a junction N-P-N type, and two of Sonotone's special microminiature vacuum tubes. A tiny "B" battery costing under a dollar will last over 6 months in the new product.

Dr. Irving I. Schachtel, president of Sonotone, told a press conference that this is the greatest revolution in hearing aids since the introduction of the bone conduction instrument 20 years ago. "It means easier, cheaper, and better hearing for thousands of persons," he said. "This first marriage of transistors and hearing aids," added Dr. Schachtel, "opens the door to an almost unlimited future in electronics miniaturization."

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MANAGEMENT CONTROLS IN INDUSTRIAL RESEARCH ORGANIZATIONS. By Robert N. Anthony assisted by John S. Day. Harvard University, Graduate School of Business Administration, Soldiers Field, Boston 63, Mass., 1952. 537 pages, tables, $8^1/_2$ by $5^3/_4$ inches, bound. $6.75. Detailed results are presented of a broad, first-hand study of the problems of administrative control of scientific research activities in American industry. Its four parts include a statement of the problem, the variable factors relating to it, current control practices, and case studies of control techniques in four specific laboratories of different sizes and kinds. Selected operating data for laboratories of different sizes and types of work are included in an appendix.

PETROLEUM GEOLOGY. By E. N. Tiratsoo. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 449 pages, tables, illustrations, charts, maps, diagrams, $9^1/_2$ by $6^1/_2$ inches, bound. $7.50. This text covers both academic questions related to the origin, migration, and accumulation of petroleum in the subsurface, and the practical problems of discovering and exploiting oil deposits. The latter include surface methods such as geological mapping, aerial surveys, and the evaluation of oil seepages, and also subsurface (geophysical) methods. The world's oil fields are reviewed, particularly with reference to their structural and stratigraphic history. The latest techniques of exploitation, including well-logging, are described, and there is a special chapter on drilling fluids.

ADVANCED STRENGTH OF MATERIALS. By J. P. Den Hartog. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 379 pages, graphs, charts, tables, $9^1/_4$ by $6^1/_4$ inches, bound. $8.50. Starting from the level attained by the first 1-term course in engineering colleges, this volume covers the following major subject headings: torsion; rotating disks; membrane stresses in shells; bending of flat plates; beams on elastic foundation; 2-dimensional theory of elasticity; the energy method; buckling; miscellaneous topics such as Mohr's circle and certain specialized theorems.

CHARTING STATISTICS. By Mary Eleanor Spear. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 253 pages, illustrations, charts, graphs, $9^1/_4$ by $6^1/_4$ inches, bound. $4.50. A liberally illustrated textbook employing drafting room methods of charting for practical graphic presentation of statistical data. Various interpretations of the same tables are used to illustrate the types of charts applicable to the given tables of facts. Among the varieties discussed are line, surface, column, bar, map, and flow charts.

ELECTRON TUBES IN INDUSTRY. By Keith Henney and James D. Fahnestock. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., third edition, 1952. 353 pages, diagrams, tables, charts, graphs, $9^1/_4$ by $6^1/_4$ inches, bound. $6.50. Beginning with basic circuit elements, tube fundamentals, and basic tube circuits, this book proceeds to discussions of the practical uses of thermionic and light-sensitive tubes outside the communication field. Subsequent chapter headings are as follows: rectifiers and power supplies; relays and relay circuits; motor control; electronic measurement and control; counters and divider circuits; high-frequency heating and welding. The different varieties of tubes are described and many examples of use given, with circuit diagrams.

ELECTRICAL DRAFTING AND DESIGN. By Calvin C. Bishop. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., third edition, 1952. 267 pages, tables, illustrations, diagrams, charts, $9^1/_4$ by $6^1/_4$ inches, bound. $4.50. This specialized text covers the more important subjects encountered in power and lighting. The text material and illustrative problems are arranged to give practice in applying tables, formulas, and charts used in everyday work (National Electrical Code, and so forth), and in making sketches, layouts, and drawings giving accurate and complete information in accordance with standardized methods. Over 100 pages of basic technical data tables are included as an appendix.

THE ENGINEER'S APPROACH TO THE ECONOMICS OF PRODUCTION. By John Reid Dick. Sir Isaac Pitman and Sons, Ltd., London, England, 1952. 248 pages, $8^3/_4$ by $5^1/_2$ inches, bound. 21s. A discussion of the engineer's problems relating to capital investment and operating costs, this book deals with the behavior of all factors determining efficient production. The application of economic theories is used to further the ideal situation of optimum efficiency with minimum costs.

FUNDAMENTALS OF ENGINEERING ELECTRONICS. By William G. Dow. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., second edition, 1952. 627 pages, tables, charts, diagrams, graphs, $9^1/_4$ by 6 inches, bound. $8.50. The author's intent is to provide, from the engineer's point of view, a realistic, quantitatively usable conception of the principles that govern the internal behavior of electronic devices and to familiarize the reader with methods of circuit analysis customarily used in connection with the most common engineering applications of these devices. Noncircuit phenomena are covered as well, for semiconductors, for instance, and within the general revision special attention has been given to ultrahigh-frequency and microwave-frequency tubes.

GRAPHISCHE BEHANDLUNG DER KOMPRESSIBLEN UND INKOMPRESSIBLEN STROMUNG DURCH TURBOMASCHINENSTUFEN. (Mitteilungen aus dem Institut für Thermische Turbomaschinen an der E.T.H., Number 2.) By Adel Gazarin. Verlag Leemann, Zürich, Switzerland, 1951. 89 pages plus charts, $9^1/_2$ by $6^3/_4$ inches, paper. Sw. frs. 13.50. A thesis dealing with 3-dimension compressible and incompressible flow between the lo blades of turbomachines. A graphical method developed which determines the radial variation of t velocity and density in the axial gap between the fix and moving blades, which, in turn, determine t characteristics of the stage and the location of t meridional stream lines.

HIGH-ENERGY PARTICLES. By Bruno Ros Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y 1952. 569 pages, graphs, tables, charts, $9^1/_2$ by 6 inches, bound. $12.50. The author's two objectiv are (1) to give a comprehensive account of our prese knowledge concerning high-energy phenomena, describe its historical development, and to explain t research methods peculiar to the field; and (2) provide the active investigator with a report on curre problems in high-energy physics and present him wi a collection of formulas, tables, and graphs useful his work. Cascade showers and the theory of electr magnetic interactions are dealt with in considerab detail.

MAGNETISCHE WERKSTOFFE. (Reine und ang wandte Metallkunde in Einzeldarstellungen, Volum 11.) By Franz Pawlek. Springer-Verlag, Berli Germany, 1952. 303 pages, tables, graphs, char $9^1/_4$ by $6^1/_2$ inches, bound. DM 42.—A comprehensi survey of the development of magnetic materials an their industrial applications, covering the literatu from 1930 through 1950. The separate sections a as follows: permanent magnets; magnetically so materials; materials for load coils and high-frequen cores; materials with large magnetostriction; speci physical properties based on latent magnetic actio materials with strong saturation magnetization; no magnetic materials. Tables of trade names, compos tion, and properties of permanent magnet materia in Germany and other countries, are appended.

DIE MESSWANDLER. (Lehr-und Handbücher d Ingenieurwissenschaften, Volume 9.) By J. Goldstei Verlag Birkhäuser, Basel, Switzerland, second editio 1952. 212 pages, diagrams, tables, illustrations, chart $9^3/_4$ by $6^3/_4$ inches, bound. Sw. Frs. 29.10. Writte primarily for practicing engineers, this treatise on th instrument transformer deals with theory, constructio details, methods of calculation, and important applica tions. Part *A* covers the current transfer; Part *B*, th voltage transformer; Part *C*, transformer tests an important measuring apparatus. Recent research an development work have been taken into account, an European and American development are compare There is a classified bibliography.

NUMERICAL METHODS IN ENGINEERIN By Mario G. Salvadori and Melvin L. Baron. Prentic Hall, Inc., 70 Fifth Avenue, New York, N. Y., 195 258 pages, tables, charts, graphs, $8^1/_2$ by $5^3/_4$ inche bound. $6.65. Numerical methods using series e pansions, successive approximations, and other no analytical solution methods are described with illustr tive problems from the fields of mechanics, strength materials, electricity, elasticity, plasticity, heat flo vibrations, and so forth. Finite difference theory is th unifying basis of the techniques which cover algebra and transcendental equations, initial value and ordina boundary value problems, and partial different equations. The numerical tools to which these tec niques can be applied are the electric desk calculat and, in many cases, the slide rule.

PRINCIPLES OF RADAR. By J. Francis Reint and Godfrey T. Coate. McGraw-Hill Book Compan Inc., 330 West 42d Street, New York 36, N. Y., thi edition, 1952. 985 pages, diagrams, illustratio tables, graphs, $9^1/_4$ by $6^1/_4$ inches, bound. $7.7 Intended primarily for those interested in the bas concepts and techniques of pulse radar, the materi has been made sufficiently general, however, to useful for anyone working in other fields employi similar techniques. The early part of the book pertai in general, to pulse circuits and their application radar modulators, indicators, and receivers. Synch and servomechanism control circuits are also work into their logical place in this section. The latter pa of the book is devoted to the radio-frequency aspe of radar. Basic concepts are developed in the chapte on transmission lines, waveguides, and resonant caviti and the techniques of their use in radar are present in the remaining chapters.

THE TECHNIQUE OF STAGE LIGHTING. Rollo Gillespie Williams. Pitman Publishing Corpor tion, 2 West 45th Street, New York, N. Y., 1952. 1 pages, illustrations, tables, diagrams, $8^3/_4$ by $5^1/_2$ inche bound. $6.00. Scientific, technical, and artis

aspects of stage lighting are discussed in this 4-part text of interest to architects, engineers, contractors, designers, and amateur enthusiasts. The divisions of the subject matter are as follows: the scientific basis; technical adaptation and control of light; the artistic effects; and practical discussions of lighting for stage productions. The illustrations include photographs of equipment, color plates, graphs, and diagrams.

VERSUCHE AN EINEM RASCHLAUFENDEN ZWEITAKET - GEGENKOLBEN-DIESELMOTOR. (Mitteilungen aus dem Institut für Thermodynamik und Verbrennungsmotorenbau an der E.T.H., Number 10.) By A. I. Ibrahim Abdelfattah. Verlag Leemann, Zürich, Switzerland, 1951. 61 pages, illustrations, charts, diagrams, graphs, 9$^1/_2$ by 6$^3/_4$ inches, paper. Sw. Fr. 7.30. This report of tests on a high-speed 2-cycle opposed-piston diesel engine covers the following points: comparison of different fuel injection systems; scavenging; control of friction losses in the engine; measurement and calculation of temperatures and heat flow in inlet and exhaust pistons.

WRITING THE TECHNICAL REPORT. By J. Raleigh Nelson. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., third edition, 1952. 356 pages, charts, 9$^1/_4$ by 6$^1/_4$ inches, bound. $4.50. The first part presents a review of those fundamental considerations which bear on the design and composition of the report. The second gives specific directions for the form and style of the report, with several examples. The third outlines a systematic procedure for the critical examination of a report. The last two parts provide a summary of basic principles and a suggested series of assignments for classroom use. The whole is designed to supply a basic approach and pattern as well as the incidentals of forms and convention.

MODERN PLASTICS ENCYCLOPEDIA AND ENGINEER'S HANDBOOK, 1952. Plastics Catalogue Corporation, 575 Madison Avenue, New York 22, N. Y., 1952. 848 pages, tables, charts, illustrations, 11$^1/_2$ by 8$^1/_2$ inches, bound. $2.00. As in the previous edition, this useful reference work presents in detail the recent developments in plastics engineering and methods, machinery and equipment, and plastics materials. The materials are now arranged in three sections: resins and molding compounds; chemicals for plastics; fillers and reinforcements. The directory section contains buyers' guides for materials, equipment, and so forth, and an extensive list of trade names. The technical data section now includes a fibers' properties chart, the plasticizers chart has been expanded, and the large folded plastics' properties chart is included as usual.

ADVANCES IN ELECTRONICS, Volume IV. Edited by L. Marton. Academic Press Inc., Publishers, 125 East 23d Street, New York 10, N. Y., 1952. 344 pages, diagrams, charts, graphs, tables, 9$^1/_4$ by 6$^1/_4$ inches, bound. $7.80. As in the previous volumes, this book presents an up-to-date review of outstanding developments in the field both in the United States and abroad. Each chapter summarizes important progress in theory, techniques, and devices made in the past year. Chapter headings are as follows: electron scattering in solids; the scintillation counter; fluctuation phenomena; electronic digital computers; modulation of continuous-wave magnetrons; the magnetic air-borne detector; multichannel radio telemetering. Reference lists follow each chapter.

ATOMIC POWER. By Walter Isard and Vincent Whitney. The Blakiston Company, 575 Madison Avenue, New York 22, N. Y., 1952. 235 pages, tables, graphs, 9$^1/_4$ by 6$^1/_4$ inches, bound. $4.75. Beginning with a brief résumé of the technical background, the authors continue with a factual analysis of the economic, sociological, political, and geographical aspects of atomic power development. Part II deals with costs and industrial applications, utilizing the iron and steel industry and the aluminum industry as case studies. Part III discusses the relation of atomic power to the process of economic development and its impact upon regional economies, with Brazil particularly considered as a case study. A considerable amount of statistical data is provided as necessary basic information.

DEVELOPMENT OF THE GUIDED MISSILE. By Kenneth W. Gatland. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 1952. 133 pages, tables, diagrams, illustrations, 8$^3/_4$ by 5$^3/_4$ inches, bound. $3.75. The author has gathered together the available facts on the evolution of guided missiles up to now, and describes their possible future developments. The range covered is indicated by the chapter headings: the new armament; air-to-air missiles; problems of the supersonic rocket; rockets for high-altitude research; space-satellite vehicles; interplanetary flight. An appendix contains tabulated information on some 90 powered-missile types considered to be of significant importance.

DIE GESTALT DER ELEKTRISCHEN FREILEITUNG. By Milan Vidmar. Verlag Birkhäuser, Basel, Switzerland, 1952. 199 pages, 9$^3/_4$ by 6$^3/_4$ inches, bound. Sw. Frs. 19.75. An analytical treatment of the design of overhead power lines, which presents theoretical, mathematical solutions of a number of important transmission problems. The topics covered are shown by the chapter headings: the design problem; span length; the cross section through the 3-phase conductor; diameter of the transmission line; the physical state of the transmission line; the problem of the conducting metal; the electromagnetic design of the overhead power line. Various other specialized aspects are dealt with within the several chapters.

HARWELL. The British Atomic Energy Research Establishment. 1946–1951. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 1952. 128 pages, plates, 9$^3/_4$ by 6 inches, bound. $3.75. A description of the establishment, its operation, and its various programs, including the fundamental research work of a general or long-range nature. A special chapter deals with the protection of health and the detection of radiation. A reading list and a brief glossary are included.

LEGAL GUIDE FOR CONTRACTORS, ARCHITECTS, AND ENGINEERS. By I. Vernon Werbin. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 374 pages, 8$^1/_2$ by 5$^1/_2$ inches, bound. $4.75. A concise review of typical problems in connection with construction contracts which describes 83 actual situations in the breaching and changing of contracts, and so forth, situations of the sort that frequently lead to litigation, and tells how the courts viewed each case. Facts and contract provisions involved are given in each situation, and cases are cited to sustain the principles of law set forth.

NATIONAL FIRE CODES. Volume II: The Prevention of Dust Explosions. 1952. Sponsored by National Fire Protection Association and approved by the American Standards Association. National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., supersedes 1950 edition, 1952. 288 pages, diagrams, charts, 9$^1/_4$ by 6$^1/_4$ inches, bound. $3. A compilation of codes established for a wide variety of industries in which dust concentrations are a hazard. Safety methods and precautions are specified for buildings, equipment, operating methods, and other pertinent aspects. Static electricity and explosion venting are discussed separately in appendixes, and there is an extensive listing of dust explosions in the United States classified by dust types.

PIPE RESISTANCE. For Hydraulic, Lubricating, and Fuel Oils, and other Non-Aqueous Liquids. By T. E. Beacham. E. and F. N. Spon Limited, London, England, 1951. 61 pages, charts, 10 by 6$^1/_2$ inches, bound. 18s. The author's object is to provide a simple and accurate means of estimating pipe resistance for all engineers, designers, and research workers concerned with the flow of nonaqueous liquids. A feature of the book is the series of pipe-resistance diagrams covering a wide range of conditions by means of which pipe sizes can be determined with ease and precision. A full explanation of the construction and use of the diagrams is given.

RADIO ASTRONOMY. By Bernard Lovell and J. A. Clegg. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 238 pages, graphs, plates, tables, charts, 7$^1/_2$ by 5$^1/_2$ inches, bound. $4. "Radio Astronomy" is the name here given to a new science that has developed since the end of the second world war. Closely allied to astronomy, astrophysics, and physics in subject matter, radio astronomy is based mainly on the use of the techniques of radio and radar. Some aspects covered are: the study of meteors by the radio echo technique; radio waves from the sun; solar radio emissions, galactic radio noise and radio emissions; and radio investigations of the moon.

STORAGE TUBES. By M. Knoll and B. Kazan. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 143 pages, diagrams, graphs, 9$^1/_4$ by 6 inches, bound. $3.50. The purpose of this book is to explain in concise form the fundamental operation of the different types of electronic storage tubes for television, computer, and signal-converter applications. Working from the underlying principles through the currently used writing and reading methods, the author concludes with condensed descriptions of a wide range of tube types, referring in each case to one or more references, in the accompanying bibliography, in which fuller treatment will be found.

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ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

STREET LIGHTING. (The Roadmakers' Library, Volume 12.) By J. M. Waldram. Edward Arnold and Company, London, England, 1952. 431 pages, illustrations, diagrams, charts, tables, 9$^1/_4$ by 6 inches, bound. $12. The first half of this new text and reference book correlates the basic mechanism of street lighting with the relevant results of theoretical work, and discusses in detail the matter of installations with special reference to the variables involved: road surface, type of traffic, curves, intersections, light distribution, special locations, and so forth. The second half covers equipment—lamps, standards, control devices, and so forth—and miscellaneous topics such as costs, maintenance, tests, and calculations. Although mainly electrical, the book also includes material on gas lighting. The main purpose of the book is to act as a guide to the satisfactory design of efficient lighting installations under all conditions.

TELEVISION. By F. Kerkhof and W. Werner. Philips' Gloeilampen-Fabrieken, Eindhoven, Holland, 1952. 434 pages, illustrations, diagrams, charts, 9$^1/_4$ by 6$^1/_4$ inches, bound. $7.75. (Available in United States from Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Tex.) Primarily for technicians and engineers with a knowledge of radio theory, this book gives the physical principles upon which television is based and develops the numerous and varied electric circuits employed in the design of modern receivers and transmitters. It discusses not only the systems used in the United States, but also those in use or projected in Great Britain and on the Continent. A glossary of terms and a bibliography for each chapter are included at the end of the book.

THEORETICAL NUCLEAR PHYSICS. By John M. Blatt and Victor F. Weisskopf. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 864 pages, tables, charts, graphs, 9$^1/_4$ by 6$^1/_4$ inches, bound. $12.50. This book deals with the theoretical concepts, methods, and considerations which have been devised in order to interpret the experimental material and to increase the ability to predict and control nuclear phenomena. The treatment is thorough and the analyses are as rigorous as is possible with a rapidly developing scientific field. The book covers general properties of the nucleus, nuclear forces and reactions, nuclear spectroscopy, the interaction of nuclei with electromagnetic radiation, beta-decay, and other allied topics. At the end of each chapter is a list of symbols used, their meanings, and the number of the equation in which the symbol is introduced and defined. Some 800 literature references are listed.

UHF PRACTICES AND PRINCIPLES. By Allan Lytel. John F. Rider Publishers, Inc., 480 Canal Street, New York 13, N. Y., 1952. 390 pages, illustrations, diagrams, charts, 8$^1/_2$ by 5$^3/_4$ inches, bound. $6.60. The first three chapters provide an introductory background by discussing the nature of ultrahigh frequencies and how they differ from lower frequencies. Succeeding chapters take up successively receiving antennas, transmission lines and wave guides, new types of tuned circuits, ultrahigh-frequency oscillators, and commercial transmitting and receiving equipment. Separate sections are devoted to developmental vacuum tubes and to ultrahigh-frequency test equipment and techniques. The book is designed for the student or technician who is familiar with standard broadcast receivers, and emphasizes practical aspects.

DAVISON'S TEXTILE BLUEBOOK. The 87th year, July 1952 edition. Davison Publishing Company, Ridgewood, N. J., 1952. 1,463 pages, $8^{1}/_{8}$ by 5 inches, bound. $6.50. A complete directory of textile mills and products. The information is arranged geographically under product, raw materials, dealers, and manufacturers. There are alphabetical indexes giving name of proprietor and mills of all textile manufacturers, dyers, finishers, and so forth, in the United States and Canada. Lists of textile schools, laboratories, associations, and so forth, and other pertinent items are included.

THE REFRIGERATION DATA BOOK. BASIC VOLUME. American Society of Refrigerating Engineers, 40 West 40th Street, New York, N. Y., seventh edition, 1951. 688 pages, 218 pages, illustrations, tables, charts, diagrams, graphs, $9^{1}/_{2}$ by $6^{1}/_{2}$ inches, bound. $7.50. This biennial reference book provides comprehensive coverage of refrigeration design, theory, thermodynamics, refrigerant properties, and related topics, the several chapters being written, as before, by authorities in the respective fields. A classified buyers' guide is also included. The complementary volume on practical applications appears in the alternate years to round out the full treatment.

THE SCIENTIFIC PAPERS OF JAMES CLERK MAXWELL. Edited by W. D. Niven. Dover Publications, Inc., 1819 Broadway, New York 19, N. Y. 607 pages, 806 pages, diagrams, illustrations, tables, two volumes bound in one. $10. This reprint of the definitive edition of 1890 contains all the published papers, lectures and addresses, essays, and short treatises of one of the great theoretical physicists of the 19th century. These clear and vigorous expositions of fundamental physical theory and experiment cover a broad range of subject matter and are still useful to the student or physical investigator.

SOUND INSULATION AND ROOM ACOUSTICS. By Per V. Brüel. Translated from the Danish by J. M. Borup. Chapman and Hall Ltd., 37 Essex Street, London, W. C. 2, England, 1951. 275 pages, tables, charts, graphs, illustrations, 9 by 6 inches, bound. 35s. The subject matter of this translation of the work of a Danish authority reflects the author's extensive practical experience. About one-half of the book is devoted to fundamental acoustical principles, physiological acoustics, fields of sound, and sound-absorbent materials and construction details. The remainder of the book deals directly with the problems of room acoustics, with actual sound insulation procedures, and particularly with effective damping methods.

TRANSPORTATION. Principles and Problems. By Truman C. Bingham and Merrill J. Roberts. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y., second edition, 1952. 710 pages, graphs, maps, tables, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6. Designed for college courses in transportation, this textbook covers railroads, motor carriers, pipe lines, airways, and inland coastwise and intercoastal waterways. These forms of transportation are treated jointly from a functional point of view with the primary purpose of promoting the establishment of more rational transportation policies. A historical and factual introduction is followed by material on transport legislation. Rate setting is thoroughly covered, and separate chapters deal with security issuance, labor relations, public aid, and other special aspects. Extensive footnotes and references are provided.

FUELS AND COMBUSTION. By Marion L. Smith and Karl W. Stinson. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 340 pages, diagrams, tables, charts, illustrations, $9^{1}/_{4}$ by $6^{1}/_{2}$ inches, bound. $6.50. A concise but comprehensive treatment of the characteristics and properties of solid, liquid, and gaseous fuels, the fundamentals of the combustion process, and the effective application of combustion principles in furnaces, oil and gas burners, internal-combustion engines, gas turbines, and rockets. Problems and literature references accompany each chapter. The chemical aspects of combustion are presented in such a way as to be readily understandable to students with an elementary background in the subject.

ULTRAVIOLET RADIATION. By Lewis R. Koller. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1952. 270 pages, illustrations, charts, tables, graphs, $9^{1}/_{4}$ by 6 inches, bound. $6.50. This book is intended to answer some of the questions which confront physicists and specialists in fields other than physics when they find it necessary to work in the ultraviolet portion of the spectrum. Important chapter subjects are arcs, incandescent sources of radiation, solar radiation, transmission, reflection, applications and effects of ultraviolet, and detectors of ultraviolet radiation. Graphs and diagrams are extensively used to supplement the text material.

ANALYSIS OF ALTERNATING-CURRENT CIRCUITS. By W. R. LePage. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y., first edition, 1952. 444 pages, charts, diagrams, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.50. This introductory text covers the usual ground of a first course and is completely devoted to the steady state in lumped linear networks. The development of the material is designed to provide an understanding of the process of analysis rather than just a compilation of techniques of solutions. The text conforms to accepted current practice in notation.

DER EIGENBEDARF MITTLERER UND GROSSER KRAFTWERKE. By Alexander Roggendorf. Springer-Verlag, Berlin, Germany, 1952. 222 pages, tables, diagrams, illustrations, charts, 10 by $6^{3}/_{4}$ inches, bound. DM 31.50. This book deals with the internal electrical requirements of steam-electric power stations. It provides chapters on energy consumed within the plant itself, selection of drive and voltage, layout of the internal network, electric equipment needed, plant supervision, control and signalling installations, and standby equipment. Schematic diagrams are extensively used to illustrate the text. There is a separate chapter dealing briefly with hydroelectric power plants.

HANDBOOK OF APPLIED HYDRAULICS. Calvin Victor Davis, editor. McGraw-Hill Book Company Inc., 330 West 42d Street, New York 36, N. Y., second edition, 1952. 1,272 pages, illustrations, diagrams, charts, tables, graphs, $9^{1}/_{4}$ by $6^{1}/_{2}$ inches, bound. $15. A general reference work on hydraulics, composed of brief, yet complete, texts on its various branches with practical information on the planning and design of hydraulic works. Hydrology, river regulation, dams, spillways, canals, hydroelectric plants, hydraulic machinery, water supply, sewerage, irrigation, and so forth, are discussed by 22 prominent engineers dealing with their specialized fields. In addition to the extensive revision in this edition, new sections have been added on water hammer, surge tanks, speed regulation, and navigation locks. Hundreds of graphs, diagrams, photographs, and detailed sketches supplement and illustrate the text.

HARMONICS, SIDEBANDS, AND TRANSIENTS IN COMMUNICATION ENGINEERING. As Studied by the Fourier and Laplace Analyses. By C. Louis Cuccia. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 465 pages, diagrams, tables, charts, graphs, $9^{1}/_{4}$ by $6^{1}/_{2}$ inches, bound. $9. Essentially two books in one, this volume treats the highly important field of the mathematics of harmonic and transient analysis applied to the communication field while at the same time providing a treatment of communication engineering in its own right. The intent is to provide an integrated approach to the use of these analyses in the important phases of electrical communications rather than just a text on "advanced mathematical methods for engineers." Recent advances in radar and television are given full consideration.

MAGNETISCHE MESSUNGEN AN FERROMAGNETISCHEN STOFFEN. By Werner Jellinghaus. Walter de Gruyter and Company, Berlin W35, Germany, 1952. 163 pages, charts, diagrams, $7^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound, DM 18. An introductory text on magnetic measurements on ferromagnetic materials intended to provide a basic understanding of present-day methods. Includes material on measurements of field strength, a-c fields, magnetic induction in a-c fields, losses, permanent-magnet materials, and so forth, while omitting the more difficult technical aspects such as magnetic properties in high-frequency fields or transition from the ferromagnetic to the papamagnetic state.

FLUX LINKAGES AND ELECTROMAGNETIC INDUCTION. By L. V. Bewley. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., 1952. 100 pages, diagrams, $7^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $3.50. The purpose of this small monograph is to explain and interpret Faraday's law on electromagnetism, and to demonstrate how this and other basic laws and concepts underlie the many applications of electrical theory which have been developed since. The special fundamental cases are dealt with separately.

PAMPHLETS • • • •

The following recently issued pamphlets may be o interest to readers of "Electrical Engineering." A inquiries should be addressed to the issuers.

Tube Production Techniques. Rapi measurements of the interface impedance o oxide-coated cathodes is made possible b the instrument described in the paper "Bridge for Measuring the Interface Im pedance of Oxide-Coated Cathodes." Th bridge is balanced at three widely differen frequencies, and the interface resistanc and capacitance are read directly fron decade units in the bridge circuit. Th results are independent of tube charac teristics. 9 pages. 25¢. Available fron the National Research Council of Canada Ottawa, Ontario, Canada.

Specifications for Copper and Copper Alloy Welding Rods. The latest speci fications for filler metal cover copper an copper-alloy welding rods for use with oxy acetylene, carbon-arc, and inert-gas metal-ar welding. The 12 classifications establishe by these specifications include copper silicon-bronze, phosphor-bronze, copper nickel, naval-brass, manganese-bronze, low fuming-bronze, nickel-bronze, and alumi num-bronze welding rods. These new speci fications give the chemical composition mechanical properties, and usability charac teristics of each classification, with corre sponding tests for verifying these propertie An appendix is included as an aid to user in selecting the best rod for their needs an using it in the most efficient way. 13 page 40¢. Copies may be obtained from eithe American Welding Society, 33 West 39t Street, New York, N. Y., or America Society for Testing Materials, 1916 Rac Street, Philadelphia, Pa.

Radio Interference Measurement. A de tailed analysis of interference tests performe on a Maico Model *H-7* Audiometer is give in a report entitled "Radio Interferenc Measurements and Modifications on Audi ometer Equipments." In this work the un was considered as both a source and a re ceiver of interference. For the equipmen considered a source of interference, eac cause of interference was analyzed separatel and the methods employed either to reduc or eliminate it completely are discussed i detail. 77 pages. Microfilm $3.50, photo stat $10.00. Available from the Library o Congress, Photoduplication Section, Wash ington 25, D. C.

Annual Report, 1951, National Bureau o Standards. Summarizing scientific an engineering investigations conducted by th Bureau during the fiscal year 1951, th booklet contains accounts of current activ ties as well as more detailed descriptions o especially important scientific development Its text provides a general description o work done in the 15 scientific and technic divisions and gives many specific exampl of significant projects during the year. 10 pages. 50¢. Order from the Governme Printing Office, Washington 25, D. C.